SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1916.

GENERAL PHYSICS.

1. *Thermo-balance.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 4. 2. pp. 97–103, 1915.)—The author has devised a thermo-balance which renders it possible to follow continuously the change in weight of a substance with gradual rise in temperature, the necessity of cooling to the ordinary temperature being obviated. The construction of, and mode of using, the balance are described. The following results have been obtained with its aid. $MnSO_4, 4H_2O$ loses $3H_2O$ at 70–110° and the remaining H_2O at 230–260°. The anhydrous sulphate exists from 280° to 820°, when it begins to decompose into Mn_3O_4, this change being complete at about 950°. $CaSO_4, 2H_2O$, loses its water of crystallisation at 180–260°. $CaCO_3$ is converted into CaO between about 500° and 880°, the rate of decomposition attaining a maximnm at 820°. The results obtained with chromic acid confirm those of the author and Soné [Abs. No. 494 (1915)]. T. H. P.

2. *Electro-magnetic Vacuum Balance.* **J. S. Anderson.** (Faraday Soc., Trans. 11. pp. 69–75, Oct., 1915. Electrician, 75. pp. 359–361, June 11, 1915. Abstract.)—One scale pan of a balance is replaced by a circular coil of wire whose axis is vertical. This coil is movable between two larger fixed coils of wire, which have the same vertical axis. The three coils are so connected that an electric current may be passed through them in series; through the movable coil and the lower fixed coil in one direction and through the upper fixed coil in the opposite direction. Thus when a current is passed through the coils the movable one is attracted towards the lower, and repelled by the upper fixed coil. These attractive and repulsive forces may be increased or decreased by increasing or decreasing the current passing through the coils; they are made use of to counterbalance the force of gravity acting on the substance to be weighed in the scale pan hanging from the other end of the beam of the balance. Should the weight of the substance vary from time to time, the variations can be determined by altering the current passing through the coils until equality of the forces acting on either end

of the balance beam is obtained. The balance is enclosed in a bell-jar which can be exhausted, so that the process of weighing can be carried out while the substance being weighed is in a vacuum. A. F.

3. *Errors in Levelling.* **W. Bowie.** (Science, 42. pp. 712–718, Nov. 19, 1915. Paper read before the Phil. Soc. Washington, March, 1915.)—Fifty years ago the error of precise levelling in geodetic survey was considered to be not more than 3 mm. per km. Nowadays this error is reduced to ± 1 mm. per km. for accidental error, and ± 0·2 mm. per km. for systematic error. There is a discussion as to possible difference in levels of the three water surfaces bounding the United States, viz., the Pacific Ocean, the Atlantic Ocean, and the Gulf of Mexico. Several conclusions, based on levelling data, are reached, among them being:—It is believed that, other things being equal, the running in the afternoon (if not within one hour of sunset) gives, on an average, more accurate results than the forenoon running; also that, a running in wind is more accurate than one in calm, and that a running with a cloudy sky is more accurate than one with sunshine. Hence the ideal condition is an afternoon with moderate wind and cloudy sky, since under those conditions irregular refraction is at a minimum. P. E. S.

4. *Young's Modulus by Sonometer.* **A. Guillet.** (Comptes Rendus, 161. pp. 561–562, Nov. 8, 1915.)—Describes a sonometer with a fine micrometer screw to tighten the wire which is 0·8 mm. in diam. and about 80 cm. long. It is thus easy to adjust the pitch over a range exceeding an octave, the pitch being very satisfactorily reproduced each time the micrometer is set to the same reading. The value of Young's modulus can also be obtained from the change of pitch caused by a given stretch of the wire. E. H. B.

5. *Harmonic Analysis of Barograms.* **F. Vercelli.** (Accad. Lincei, Atti, 24. pp. 1120–1125, June 24, 1915.)—Applies Chrystal's graphic method to the analysis of Italian barographic records of the years 1907 to 1914, and shows that the barometric oscillations in question would result from a certain number of damped harmonic vibrations of constant period independent of the place and time of observation, just as if they were due to the free oscillation of the whole atmosphere. E. E. F.

6. *Length of Invar Steel Wires.* **L. Carnera.** (Accad. Sci. Torino, Atti, 50. pp. 85–96, 1914–1915.)—The author finds that invar steel wires 24 m. long, used for geodetic purposes and wound on a reel, can be relied upon to remain constant to within one-millionth of their length. E. E. F.

7. *Harmonic Analysis.* **H. O. Taylor.** (Phys. Rev. 6. pp. 303–311, Oct., 1915.)—Simple methods of obtaining the constituent harmonics have been devised for waves which have odd harmonics only, so that schedules for computing the amplitude and phase of the harmonics may be constructed by a mechanical process. The present paper outlines a simple mechanical process for constructing complete schedules for the analysis of waves containing even, as well as odd, harmonics, and also points out how a single schedule may be made for any particular harmonic. A. W.

8. *Relativity Theory of Gravitation.* **J. Ishiwara.** (Tôhoku Univ., Sci. Reports, 4. 2. pp. 111–160, 1915.)—A mathematical treatise on the subject in the vector analysis of four-dimensional space. E. H. B.

9. *Motion of a Stream of Finite Depth past a Body.* **R. Jones.** (Roy. Soc., Proc. 92. pp. 107–121, Dec. 1, 1915.)—A mathematical consideration of the thrust on a body past which is flowing a stream (1) with free boundaries, and (2) in a channel with rigid boundaries. J. W. T. W.

10. *Rise and Fall Experiments on Particles with Brownian Motions.* **E. Schrödinger.** (Phys. Zeits. 16. pp. 289–295, Aug. 15, 1915.)—A mathematical discussion of the theory of the fall under gravity and rise in an electrical field, of particles subject to Brownian movements, the probabilities of collisions being dealt with. [See Abs. 1270 (1909) and 1091 (1915).] E. H. B.

11. *Rise and Fall Experiments on Particles and Brownian Motions.* **D. Konstantinowsky.** (Phys. Zeits. 16. pp. 369–372, Oct. 15, 1915.)—Discusses the work and views of F. Ehrenhaft and E. Schrödinger on this subject [see Abs. 1091, 1196 and 1367 (1915)]. E. H. B.

12. *Properties of Spherules of Pure Mercury.* **A. Schidlof.** (Phys. Zeits. 16. pp. 372–375, Oct. 15, 1915.)—Remarks on F. Ehrenhaft's paper on smallest mercury spherules [see Abs. 1569 (1914), 1367 (1915)]. E. H. B.

13. *Air-resistance.* **M. Panetti.** (Accad. Sci. Torino, Atti, 50. pp. 488–494, 1914–1915.)—Determines experimentally the coefficient of air resistance in the case of a "Renard vane," consisting of two thin rectangular plates mounted at the ends of a revolving rod, the plane of the plates being parallel to the axis of rotation. This coefficient can be put in the form $K = 0{\cdot}305p + 0{\cdot}0806$, where $p = (R - r)/(R + r)$ and R, r are the distances respectively of the outer and inner edges of the plate from the axis of rotation. When $p = 0$, K becomes the ordinary coefficient of translational resistance. E. E. F.

14. *Air-resistance.* **F. Burzio.** (Accad. Sci. Torino, Atti, 50. pp. 697–710, 1914–1915.)—A further study of the coefficient dealt with in the preceding Abstract, to determine whether the relation between K and p is really linear, and to ascertain the effect of altering the ratio of length to width in the vanes. The author finds that the relation is practically linear except for very small values of p (*i.e.* for nearly pure translational motion) where it tends to become parabolic. E. E. F.

15. *Frictional Resistance to the Motion of Elongated Bodies through Fluids.* **C. H. Lees.** (Roy. Soc., Proc. 92. pp. 144–157, Dec. 1, 1915.)—A mathematical consideration of the motions of very elongated bodies moving parallel to their lengths through fluids in which stream-line motion is produced. Values of the resistances per unit area of contact with the fluid, and of the total resistances are found for (i) a fluid moving in the annular space between a circular pipe and concentric core, (ii) a fluid moving through a cylindrical pipe, (iii) a long body of elliptical section in motion through a fluid, with circular and straight line sections as limiting cases, (iv) a long body of rectangular section moving through a fluid, and (v) a long wide surface from which a keel projects with its length along the line of motion. In all cases the law of resistance may be expressed in a simple form, and measurements of the resistances in the corresponding cases for turbulent motion are now in progress. [Ibid. p. 144; as footnote: Corrigenda to a previous paper, see Abs. 582 (1915).] J. W. T. W.

16. *Theory of the Gyroscope.* **H. Lamb.** (Roy. Soc. Edinburgh, Proc. 35 pp. 158–161, 1914–1915.)—The object of this paper is to obtain briefly the *intrinsic* equations of motion of a gyroscope, and to show how they lead immediately to the solution of a number of problems. Apart from their use as a basis for calculation, they have a simple interpretation which enables us to foresee the general character of the motion in cases where the actual calculation would be difficult.

It is assumed that two of the principal moments of inertia at the "fixed point" O are equal, and the three moments are accordingly denoted as usual by A, B, C. Further, C is used to denote one of the two points in which the axis of symmetry meets a unit sphere having its centre at O. For definiteness the author chooses that point of the pair which is such that the angular velocity n about the axis OC shall be right-handed. This point C may be called the *pole* of the gyrostat, and it is with its path that we are concerned. From C, on the unit sphere is drawn a quadrant CA tangential to the path and in the direction of motion, and a quadrant CB at right angles, so that OA, OB, OC (in this order) shall form a right-handed system. The positions of the corresponding lines after time δt are denoted by OA′, OB′, OC′. If v be the velocity of the pole along its path, and $\delta\chi$ the angle between the projections on the tangent plane to the sphere of two consecutive tangent lines to the path, we have—

$$CC' = v\,\delta t, \quad AC'A' = \delta\chi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

At the instant t the component rotations about OA, OB, OC are 0, v, n respectively and the components of angular momentum are accordingly

$$0,\ Av,\ Cn \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

In the time δt these are altered to

$$0,\ A(v + \delta v),\ C(n + \delta n) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

about OA′, OB′, OC′ and therefore to

$$-Av\,\delta\chi + Cnv\,\delta t,\ A(v + \delta v),\ C(n + \delta n) \quad \ldots\ldots\ldots\ldots\ldots(4)$$

about OA, OB, OC, terms of the second order being neglected.

If, as is here supposed, the external forces have zero moment about the axis of symmetry, they may be replaced by two forces P, Q acting at C along the tangents to the arcs CA, CB respectively, *i.e.* along and at right angles to the path of C. P is, in fact, the moment of the external forces about OB, and $-$Q is that about OA. Hence, equating the increments of angular momentum to $-Q\delta t$, $P\delta t$, 0 respectively, we find

$$Av \,.\, d\chi/dt = Q + Cnv, \quad A \,.\, dv/dt = P \quad \ldots\ldots\ldots\ldots\ldots(5)$$

with $n =$ constant. These are the equations which the author calls "intrinsic," as involving no arbitrary lines or planes of reference. The expressions dv/dt and $v\,d\chi/dt$ are the accelerations of the pole C along and at right angles to its path on the sphere.

If $n = 0$ we have as a particular case the equations of motion of a particle on a spherical surface, and it may be inferred that the motion of the pole C in the present case will be exactly the same as that of such a particle, of mass A, under the same forces P, Q, provided there is introduced in addition a fictitious *deviating force* Cnv acting always towards the *left* of the path, as viewed from without the sphere. This statement includes the old rule about "hurrying on the precession," but is more precise and of more general application. The examples following in the paper are intended mainly to illustrate its convenience. E. H. B.

17. *Comparison of Optical and Electrical Measurements of the Thickness of Soap Films.* **A. Hagenbach** and **W. Rickenbacher.** (Archives des Sciences, 40. pp. 329-332, Oct., 1915. Paper read before Soc. Suisse de Physique.)—The authors have measured the electric conductivity of soap films by a method previously described [Abs. 1840 (1913)]. From the measurements made in the first and second black region it appears that the concentration of sodium oleate has a scarcely measurable influence on the thickness of the film. The mean values obtained show that there is, in general, agreement between the thickness measured optically and electrically. This applies also when the thickness of the film lies above 300 $\mu\mu$. Between 300 $\mu\mu$ and the black, that is, in the region of Newton's rings of the first order, the thickness measured electrically is always too great—sometimes even in the neighbourhood of 150 $\mu\mu$, the electrical value is double that obtained optically. A. F.

18. *The Hottest Region in the United States.* **G. H. Willson.** (Monthly Weather Rev. 43. pp. 278-280, June, 1915.)—The highest shade temperature ever recorded in any portion of the world under standard conditions of exposure was measured at Greenland Ranch, Death Valley, in south-eastern California, on July 10, 1913, when the maximum reached 134° F. The temperature records at Greenland Ranch now cover a period of 4 years. The average max. daily temperature has exceeded 110° F. in every July and August in the 4 years and has exceeded 115° F. in 6 out of these 8 months. In the winter a temperature as low as 15° F. has once been recorded. A table summarising the results of the 4 years' observations is given in the paper. J. S. Di.

19. *A See-saw of Pressure, Temperature, and Wind Velocity between the Weddell Sea and the Ross Sea.* **R. C. Mossman.** (Roy. Soc. Edinburgh, Proc. 35. pp. 203-216, 1914-1915.)—Four years' data are discussed in three-monthly groups. The observations refer to M'Murdo Sound (Ross Sea) on the one hand and to stations in the South Orkneys and Graham's Land (Weddell Sea) on the other. The difference in longitude between the two districts is about 120°. It is found that seasonal departures from the normal of barometric pressure are of opposite sign in the two areas, out of the 16 seasons discussed there being only 3 in which the divergences are of the same sign. The wind-velocity variations show a similar see-saw effect. As regards temperature there is pronounced opposition in the departures for the winter season, but for the other periods of the year the results are indefinite. In the later part of the paper conditions at M'Murdo Sound are compared with those at stations in temperate latitudes widely separated from it, and certain similarities and oppositions in the fluctuations are found. Great changes occur from year to year or between groups of years in the Antarctic circulation. Thus the mean wind velocity in M'Murdo Sound during Scott's first expedition (1902-04) was only half that recorded during the second expedition (1911-12), and from the Weddell Sea data it appears that storms were frequent and violent from 1902 to 1906, while from 1907 to 1914 few have been experienced. J. S. Di.

20. *Internal Reflection as a Source of Error in the Callendar Sunshine Receiver.* **E. R. Miller.** (Monthly Weather Rev. 43. pp. 264-266, June,

1915.)—The horizontal receiving grids in the Callendar recorder are placed within an elongated glass bulb the upper part of which is hemispherical in shape while the lower tapers off in a cone. The base of the hemispherical upper portion coincides with the plane of the grids. The reflection of the sun's rays from the lower portions of the glass container is found not to be of much importance, but that from the inner surface of the upper hemisphere produces a concentration of radiation on some one portion of the grids. The correct action of the instrument is dependent upon an equal amount of radiation falling upon the bright and black grids, and since the concentrated reflected light from the interior of the glass bulb will usually fall upon one grid only, an error in the readings is thereby introduced. Furthermore, as the sun moves round in azimuth the excess radiation will fall first upon one grid and then upon another, and thus the error will change sign. If the position of the grids remains unchanged this effect will continue the same from day to day, and thus a fictitious element will be introduced into the diurnal variation. Some direct experiments were made by turning the receiver through 90° so that the reflected radiation was suddenly changed from a grid of one kind to one of the other kind, and it was found that the error produced was appreciable. [See Abs. 400 (1915).] J. S. Dl.

21. *Atmospheric Pollution in English and Scottish Towns.* **J. B. C. Kershaw.** (Engineer, 120. pp. 473–475, Nov. 19, 1915. Met. and Chem. Eng. 13. pp. 967–971, Dec. 15, 1915.)—Observations with a standard type of dust and soot collecting gauge [see Abs. 1209B (1913)] have been made in 16 towns for a period in most cases of over one year. The figures obtained are summarised in a table. The largest soot and dust fall is recorded from Oldham with 81·2 metric tons per km². per month. Manchester (Ancoats) comes second with 26·8 tons, whereas Malvern shows only 2·1 tons. The Oldham fall is equivalent to 957 tons per sq. mile per annum. Another table sets out the proportions of the insoluble deposits, tar, carbonaceous matter, and ash. Figures which have been given for the soot and dust fall of Pittsburg (33·6 metric tons per km². per month) show that the amount deposited there is considerably in excess of the amount in Sheffield (21·7), the English steel-making centre. It is suggested that observations made on the Rotherham side of Sheffield might have approximated more closely to those of Pittsburg, the prevailing winds carrying the smoke to the Rotherham side of the city. A special type of recording actinometer which has been devised for measuring the intensity of sunlight illumination and used in different parts of Manchester is described and illustrated. The record is made on specially prepared photographic paper. It was found that the average intensity of sunlight on the roof of the School of Technology (100 ft. high) was 12·6 % greater than that at the ground-level. Measurements with this actinometer are also to be made for comparative purposes at Abergele in North Wales, away from the polluted atmosphere of towns. J. S. Dl.

22. *Rotation of the Earth.* **H. Glauert.** (Roy. Astron. Soc., M.N. 75, pp. 685–687, Oct., 1915.)—In a previous paper [Abs. 817 (1915)] the errors of position of the sun, Venus, and Mercury were analysed on the hypothesis that they were due to minute irregularities in the rate of the earth's rotation, and the resulting curve for the errors of the earth showed considerable similarity to that of the moon as given by E. W. Brown. On the assumption that the error in heliocentric longitude of a planet is proportional to its mean motion, three separate determinations of the errors of the positions of the earth or sun have been made. These showed a satisfactory agreement, and the mean resultant curve closely resembled the curve of the moon's error of longitude. For further confirmation the errors of Venus have been examined, and these agree both in scale and nature of variations with the adopted hypothesis of slight variations in the rate of rotation of the earth. Curves are given showing the heliocentric errors of Venus and the earth. C. P. B.

23. *Variation of Latitude at Rome.* **E. Bianchi.** (Accad. Lincei, Atti, 24. pp. 1115–1119, June 24, 1915.)—Shows from observations of latitude made at Rome, 1911–1913, that the third-term coefficient z is confirmed both in period and amount, in a manner which accords with the hypothesis of Hirajama. E. E. F.

24. *Experimental Studies and Observations on Ice Structure.* **O. D. v. Engeln.** (Am. J. Sci. 40. pp. 449–478, Nov., 1915.)—The experiments were planned primarily to secure data bearing on the structure and flow of glacial ice. In the main they consisted of compression tests (I) on cubes of ice unsupported at the sides, and (II) on cylinders of ice enclosed in metal cases of varying degrees of resistance up to complete rigidity under the pressures applied. The tests were made with screw presses specially designed and calibrated, and both pond and glacier ice were used, in cubes ½ in., 1 in., and 2 in. square, and variously oriented with regard to the component crystal structure of the ice. It was found that the crushing strength of pond ice with pressure applied in the direction of the principal axes of the component crystals (all similarly oriented) is about 1000 lbs. per sq. in. With pressure at right angles to the principal axes the crushing strength was approximately 850 lbs. per sq. in., while that of glacier ice with variously oriented crystal grains was intermediate between 850 and 1000 lbs., tending to the higher rather than the lower figure. Variations between 10° F. and 25° F. do not seem to have a notable effect on the strength of the ice. The values of crushing strength are notably higher than those cited by H. T. Barnes recently. The discrepancy is probably due to the following factors: (*a*) River ice was used by Barnes and may not have had uniformly oriented crystals due to current action, especially as large size blocks are used; (*b*) the tests were made at air temperatures only a few degrees below freezing-point and in some cases above; (*c*) the pressures were applied with comparative rapidity. It was repeatedly noted when working with cubes under pressure approaching the crushing point that cracking occurred when the pressure was relieved, and that if the pressure released was at all rapid the ice actually broke apart. This indicates that ice yields elastically to pressures slowly and carefully applied, and that the elastic rebound is not sufficiently rapid to enable the ice to withstand quick release of pressure, hence the differential stresses set up by the rapid release suffice to rupture the mass. On account of this elasticity it appears that there cannot be any permanent deformation of ice until a certain minimum stress has been applied, and the experiments showed that the yield-point is near the crushing strength of the ice. If, however, pressures just below the crushing strength of the ice are applied and continued for a sufficiently long time the ice will yield by flow without breaking. Various kinds and forms of ice, also snow, were compressed in metal cylinders to determine (1) whether any change in crystalline structure could be brought about by pressure only, and if so of what nature, and (2) whether actual continuous flow of ice could be induced by pressure at temperatures sufficiently low to render pressure melting and regelation inoperative. The ice mass was

found to be completely recrystallised, and, further, the crystals extended straight across the cylinder instead of radially inwards as might have been expected by analogy to the structure of cakes of can-frozen artificial ice. In no case were any traces of brecciation apparent. Elongated form and wedge-shape terminations in the artificial crystals produced owe their difference from glacier grains to the fact of no movement in the ice mass being involved. It seems from these experiments that a granular ice can be developed from snow by pressure with accompanying movement at air temperatures eliminating the possibility of pressure melting and regelation. The author devotes a considerable amount of space to the interpretation and application of the experiment. Under normal atmospheric pressure the orientation of ice crystals is determined by the position of the original surface or centre of refrigeration, consequently the orientation of glacier grains is determined by the position of the crystal axes in the original snow and névé grains. An ice crystal has been found to be made up of molecularly thin, flexible laminæ lying in a plane normal to the principal axes. Under pressure, with the ends of the principal axes supported, these laminæ will glide over one another, and this gliding property may account for such uniform orientation of ice crystals in the basal layers of glaciers as may exist. Ice masses do not consist of single crystals, but of aggregates of comparatively small units variously oriented. The resistance of such masses to deforming stresses would appear to be due to three factors: (*a*) the nature of the interlocking of the units, (*b*) the molecular cohesion of the ultimate particles of a unit crystal, (*c*) the molecular cohesion existing at the contact of adjacent crystal faces. It follows that experimental studies of ice under compression with reference to glacial phenomena should be directed towards ascertaining the behaviour of ice as a crystalline aggregate rather than to the investigation of the physical properties of unit crystals.

The author summarises the phenomena of a valley glacier as follows: In the reservoir area the increasing depth of accumulating snow gradually augments the pressure on its bottom layers. In the mass, meanwhile, the growth of ice crystals proceeds by molecular transference of particles and the absorption of small grains by adjacent larger nuclei. At the same time the saline matter is being segregated in the intergranular spaces. Compression itself involves a rise of temperature, and this is further increased by inflow of surface heat and heat from the earth. When pressure and heat attain sufficiently high points, flow is initiated. During the period of snow accumulation the snow and ice mass in the reservoir is under practically uniform pressure. Once flow is started non-uniform pressures are introduced, with resulting increases and decreases of the interstitial films. The continued movement of the ice tongue so started results both from the pressure due to its own thickness and the thrust from the up-slope continuation of the tongue. If the snow supply in the reservoir is cut off, an equilibrium of pressures will be established and the glacier will then melt away without further flow. If the snow supply is insufficient to provide great enough accumulations for continuous flow pressures, there will be alternative waves of advance and stagnation. The surface portions of the ice tongue are relatively rigid and brittle. The viscous underflow gives rise to tensional and shearing stresses in the upper, rigid ice layers with resulting crevassing. These crevasses are commonly developed on a greater scale in the upper ice tongue, partly because slopes are steeper, partly also, probably, because the ice of the upper portions of the ice tongues is colder. In the lower expanded portions of ice tongues pressure-temperature equilibrium has been established throughout the thickness of the ice, hence flow is possible over lower slopes and with thinner ice than at and above the névé line. Near-surface melting in the lower parts of the tongue is localised in the intergranular spaces; the resulting water tends to drain away and thus leaves the ice grains loose in the socket. On the bottom of the glacier, near the very front, the establishment of pressure-temperature equilibrium combined with the continued inflow of earth-heat and friction may result in pressure melting and thus give rise to submarginal glacial streams, whose volume is augmented by the surface-melting water percolating through the frontal portions of the melting ice tongue or finding its way to the bottom through crevasses and moulins. In the middle portions of the flowing ice tongue three separate zones may be conceived as existing from the surface to the bottom. At the top is the brittle, crevassed mass, below it the viscously flowing ice, and under that a colder ice layer, continuing to the bottom, which is being plastically deformed by reason of the pressure of the overlying ice and the frictional pull that the viscous intermediate layer is exerting on its upper surface. On this basis a decreasing rate of flow from the surface to the bottom of a glacier could be accounted for, and a greater erosive power could be ascribed to the relatively more rigid, colder bottom layers. [A fuller account giving records, data, and methods followed in individual experiments is to be found in the Zeits. f. Gletscherkunde, vol. 9. pp. 81–139, 1915.] H. H. Ho.

25. *The Constant of Aberration.* **G. Boccardi.** (Accad. Sci., Torino, Atti, 50. pp. 649–671, 1914–1915.)—Makes a new determination of the aberration constant by the method of double inversion, applied to observations of α and δ Cygni. The value obtained for the annual constant is 20·507″ ± 0·0040″, with a mean error not exceeding 0·01″. The international value 20·47″ adopted by the Paris Congress of 1896 is certainly too small. E. E. F.

26. *Astrophotometry with Photoelectric Cell.* **P. Guthnick.** (Deutsch. Phys. Gesell., Verh. 16. 24. pp. 1021–1032, Dec. 30, 1914.)—Experiments have been made in stellar photometry at the Berlin-Babelsburg Observatory, using the 30-cm. refractor in conjunction with a photoelectric cell with potassium kathode, controlled by an electrometer of the Wulf type. Illustrations of the light-curves of several variables are given, including β Cephei, α Canum Venaticorum, γ Bootes, α Geminorum, and also of the variation of the light of Mars during its rotation with reference to the earth. C. P. B.

27. *Series in Corona Spectrum.* **P. Carrasco.** (Comptes Rendus, 161. pp. 631–632, Nov. 22, 1915.)—In the electronic theory of the corona spectrum, Nicholson has suggested a relationship to exist in the lines λλ5303, 4359, and 3534. Carrasco points out that the new line photographed by him during the total solar eclipse at Theodosia, Aug. 21, 1914, at λ6374·2, appears to fit in satisfactorily as a member of the same series. Various combinations of series are also suggested for lines of the corona spectrum other than the above. C. P. B.

28. *Variations of Solar Faculæ.* **H. Arctowski.** (Comptes Rendus, 161. pp. 484–487, Oct. 11, 1915.)—In the discussion of records of solar activity most attention appears to have been devoted to the sun-spots, although detailed measurements are also available of the areas of faculæ. The author has plotted the values for faculæ, and finds that while the curves for these and sun-spots are in general very similar, there are distinct differences in the

short-duration oscillations. It is found that when approaching a maximum or minimum, the faculæ appear to last longer than the spots, attaining their max. development about 9 days later. An attempt is made to explain the fact by considering Deslandres' view of the spots as powerful descending vortices in faculic areas, the surface disturbances constituting the faculæ continuing to increase after the max. development of the spot area. [*Errata.* Ibid. p. 688, Nov. 29, 1915.] C. P. B.

29. *Variations of Faculæ and Sun-spots.* **H. Arctowski.** (Comptes Rendus, 161. pp. 485–487, Oct. 26, 1915.)—Seeking for evidence connecting the variations of solar activity and short-period changes of terrestrial climatic conditions, an investigation is made of the ratios of faculæ areas to sun-spot areas for each solar rotation during the period 1875–1918, using the records given in the *Greenwich Observations.* The means for each consecutive 10 rotations are then plotted, the resulting curves exhibiting interesting features, 5 maxima being shown during the 11-yearly period of spot areas. The ratio of facula area to spot area varies considerably, from 2·42 to 78·74, and it is suggested that if the faculæ are evidences of solar atmospheric vertical circulation, then the great variations shown would very probably result in variations of the heat emitted by the sun at different times. [See preceding Abs.] C. P. B.

30. *Albedo of the Moon.* **J. Evershed.** (Nature, 96. p. 369, Dec. 2, 1915.)—Observing the full moon rising in the neighbourhood of snow-topped mountains in the Kashmir Valley, the author was struck with the intense whiteness of the lunar disc, and doubts if the appearance can be reconciled with the idea of the lunar surface being composed of rocks of any of the types known on the earth. C. P. B.

31. *Identification of Minor Planets.* **L. Picart.** (Comptes Rendus, 161. pp. 487–488, Oct. 26, 1915.)—A formula is developed for utilising the rectangular coordinates determined from photographic determinations of two positions of a minor planet, with the object of facilitating the identification. C. P. B.

32. *Radial Velocity of Andromeda Nebula.* (Roy. Astron. Soc. Canada, J. Sept., 1915. Nature, 96. p. 271, Nov. 4, 1915. Abstract.)—Recent determinations of the radial velocity of the Andromeda nebula at Mt. Wilson indicate a motion of recession of 329 km. per sec. The spectrogram was exposed for 34 hours on five consecutive nights during Nov., 1914, by means of a small slit spectrograph at the primary focus of the 60-in. reflector. No evidence was detected of the presence of bright lines, or any indication of rotational displacement. C. P. B.

33. *Stellar Radial Velocities and Solar Motion.* **C. D. Perrine.** (Astrophys. J. 42. pp. 305–311, Nov., 1915.)—Examination of the residual radial velocities of stars grouped according to spectral type showed certain systematic variations in relation to region, the average appearing to be a minimum not far from the solar antapex, and a maximum near the apex. The values of the solar motion deduced from the different spectral classes separately show large and systematic variations. C. P. B.

34. *Faint Star with Large Proper Motion.* **R. Innes.** (Union Observatory of S. Africa, Circ. No. 30. pp. 285–286, Oct. 12, 1915.)—Examination of two photographs of the region near *α* Centauri on 1910 April 10 and 1915

July 30, resulted in the detection of a faint star having a proper motion of about 5" per annum in the direction 280°. If this is confirmed the star would rank 6th in the list of stars having great proper motions. The visual magnitude of the star is about 10, colour yellow. C. P. B.

35. *Measurement of Proper Motions with Blink-microscope.* **R. Innes.** (Union Observatory of S. Africa, Circ. No. 28. pp. 215–220, Sept. 3, 1915.)—Sets of plates of selected regions taken with the astrographic equatorial at the Cape Observatory at intervals of about 16 years have been examined in the blink-microscope for determinations of stars showing large proper motion. Out of 1600 stars on 6 plates, only 16 were found to have proper motions exceeding 0·10" a year. It is suggested that a preliminary survey in this manner of the *Carte de Ciel* plates would allow of the detection of all large-proper-motion stars with very little labour, and then attention could be specially devoted to them for definitive determination of the proper motion. Some criticisms are appended by S. S. Hough, Astronomer Royal at the Cape. C. P. B.

36. *Orbital Elements of Three Eclipsing Variables.* **J. Q. Stewart.** (Astrophys. J. 42. pp. 315–320, Nov., 1915.)—From the light curves of the eclipsing variables TW Andromedæ, TU Herculis, and RS Vulpeculæ, computations are made of their orbital elements on the two assumptions of uniform and limb-darkened discs. C. P. B.

37. *Orbital Elements of Eclipsing Variable SX Draconis.* **W. van B. Roberts.** (Astrophys. J. 42. pp. 312–314, Nov., 1915.)—Discussion of the magnitude variations resulted in concordant values for the elements on the assumption that a bright spherical star was eclipsed by a larger and fainter companion, different data, however, being employed according as the components are assumed to have discs of uniform brightness or darkened towards the limb. [See Abs. 1664 (1912).] C. P. B.

38. *Inequalities in Period of Eclipsing Variable RT Persei.* **R. S. Dugan.** (Roy. Astron. Soc., M.N. 75. pp. 692–702, Oct., 1915.)—The variability of the star RT Persei (B.D. + 46° 740) was detected in 1904 by Madame Ceraski, and observations have been continued by various workers. During the years 1905–8 the author made 904 observations, each consisting of 16 readings, with a Pickering polarising photometer. Blajko and Graff found the period to be 20h. 23m. 11s., and two years later the author found this to be about 7 minutes too long, indicating an irregular variation. Further information has been obtained from the Harvard photographs of the star, and a new set of elements are computed. C. P. B.

39. *Orbit of Spectroscopic Binary B.A.C. 5890.* **F. H. Parker.** (Roy. Astron. Soc. Canada, J. Sept., 1915. Nature, 96. p. 271, Nov. 4, 1915. Abstract.)—A spectroscopic study of this binary system has been made at the Ottawa Observatory, and in order to fill in gaps where the dispersion of the instrument was insufficient to separate the lines plates were utilised from the series obtained at the Lick Observatory. The spectrum is the F type; period 26–27 days, and eccentricity 0·49. C. P. B.

40. *Distribution of Spectroscopic Binaries of Class M.* **C. D. Perrine.** (Astrophys. J. 42. pp. 370–371, Nov., 1915.)—Ten stars of spectral class M are known to be spectroscopic binaries, or at any rate to show evidence

of variable radial velocity. With one exception these show a preference for the Milky Way, in contrast to the almost uniform distribution over the sky of the other stars of class M. The average galactic latitude of the 9 stars is 9°. Only two of the orbits are known, those of α Orionis and α Scorpii, and these are compared with certain of the orbits of Cepheid-Geminid variables. The radial velocities are comparatively small. C. P. B.

41. *Formulæ for Computing Spectroscopic Binary Orbits.* **G. F. Paddock.** (Lick Observatory, Bull. 8. [No. 274] pp. 153–179, 1915. Nature, 96. p. 547, Jan. 13, 1916. Abstract.)—Spectroscopic binaries may be divided into two classes, according as they show single or double spectra. The former furnish the means of determining six elements of the orbit, while double spectra furnish in addition the semi-amplitude of the secondary oscillation. From the two semi-amplitudes certain other factors may then be indirectly computed. Details are given of the derivation of the requisite formula for computing the orbits. The method is used in the case of the spectroscopic binary $41\nu_4$ Eridani, spectral class B9A. C. P. B.

42. *Light-changes of R Coronæ Borealis.* **E. C. Pickering.** (Monthly Register of Soc. of Practical Astron. Harvard College Observatory, Bull. 585. Aug. 14, 1915. Nature, 96. p. 154, Oct. 7, 1915. Abstract.)—During the summer of 1915 attention has been drawn to a gradual diminution in brightness of this variable. July 24, mag. 6·8; July 25, mag. 6·9; Aug. 13, mag. 7·7. C. P. B.

43. *Light-curve of RZ Cassiopeiæ.* **E. Paci.** (Soc. Spettroscop. Ital., Mem. Sept., 1915. Nature, 96. p. 353, Nov. 25, 1915. Abstract.)—Observations of this variable have been made through a number of minima at the Catania Observatory by means of a wedge photometer on a 15-cm. refractor. The magnitude ranged from 5·9 to 7·8 in 2h. 45m. C. P. B.

44. *Supposed Large Proper Motions of Stars near M* 11. **E. E. Barnard.** (Comptes Rendus, 161. pp. 411–412, Oct. 4, 1915.)—Attention has already been drawn by J. C. Solá to certain large proper motions, detectable by stereoscopic means among stars near the cluster M 11 [Abs. 1511 (1915)]. The present author has examined photographs of the region taken at an interval of 22 years, and states that no movement is visible in any of the stars in question. Moreover, the measures made visually and photographically during recent years have given no indication of proper motion. C. P. B.

45. *Colour Index of S Cephei.* **H. S. Leavitt.** (Harvard Coll. Obs. Circ. No. 188. Nature, 96. p. 323, Nov. 18, 1915. Abstract.)—This star is a circumpolar variable of long period, and coloured deep red. From a comparison of visual and photographic magnitudes its colour index is found to have the unusually large value 5 at its maximum phase. This probably increases as the star passes to minimum. The visual magnitudes range from 7·7 to 10·8, and the photographic from 12·62 to 16·0. C. P. B.

LIGHT.

46. *Lens Refractometer.* **H. F. Dawes.** (Phys. Rev. 6. pp. 354–357, Nov., 1915.)—The author describes a type of refractometer for liquids, consisting of a double convex lens silvered on its back surface. A plane-parallel glass plate holds a drop of the liquid under test against the front surface. The position of an object is found so that light traversing the system is reflected from the silvered surface and forms an image by the side of the object. This position depends upon the refractive index of the liquid and a relation of the form $\mu = c_1 - c_2/(p - c_3)$ holds, where c_1, c_2, and c_3 are optical constants, and $p =$ distance of object from lens. Thus the arrangement is suitable for a calibrated instrument. It is shown that the instrument is quite as sensitive as the calibrated type of total-reflection refractometer.

T. H.

47. *Precision Artificial Eye.* **H. E. Ives.** (Phys. Rev. 6. pp. 334–344, Nov., 1915.)—Describes a modification of the apparatus for the spectroscopic synthesis of colour, by means of which any wave-length sensibility curve can be exactly reproduced on the thermopile-galvanometer system. The apparatus consists of a spectrometer forming a spectrum which is passed through a template of such a shape that the energy transmitted at each wave-length is in correct proportion to the whole. These transmitted portions are then recombined upon a sensitive thermo-junction. This apparatus may be used for determining the transmission of the coloured screens used for eliminating colour differences in photometry, and for measuring the colours of illuminants in terms of such units as the fundamental blue, green, and red sensations determined by Koenig.

J. W. T. W.

48. *Gyro-telescope.* **C. Dienstbach.** (Scientific American, 113. pp. 363 and 368, Oct. 23, 1915.)—Gives an illustration and description of the Sperry gyro-telescope, which permits of the accurate aiming of bombs and gunfire on board airships. The instrument is a modification of the Sperry inclinometer, and is so arranged as to keep a telescope, supported on universal joints, pointed at an unchanging angle to the horizon. By a set-screw the telescope may originally be placed either in a vertical position, which is then rigidly maintained, or at any angle to the vertical direction. The slight periodic oscillations in this instrument are both very small and slow, so that for sighting or spotting purposes the telescope is practically rigid. The method of use for bomb dropping is the same as in Scott's experiments, whose sighting telescope differed only in its lack of reliability, because it was crudely controlled by a pendulum.

A. W.

49. *A Revolving Cloud Camera.* **O. L. Fassig.** (Monthly Weather Rev. 43. pp. 274–275, June, 1915.)—The axis of the camera is inclined to the horizon at an altitude of 45°, and the lens covers an angular field of 90°. The camera revolves about a vertical axis, so that after one complete revolution the whole sky has been brought within the field of view. As at present constructed the photograph is taken upon a circular plate which revolves under the lens as the camera turns, but it is proposed in future instruments to use a conical film, which will simplify the manipulation and render the camera more compact. A photograph showing the whole sky upon a circular print is reproduced, and attention is called to the advantages of being able to obtain such comprehensive cloud photographs. J. S. Di.

50. *The Modern Rangefinder.* **F. J. Cheshire.** (Phot. J. 55. pp. 250–265, Nov., 1915. Traill-Taylor Memorial Lecture.)—The modern rangefinder, in its most important form, is an optical angle-measuring instrument in which two rigidly connected telescopes, with their entrance-pupils at a short distance apart, have a common eyepiece in which the two fields-of-view are seen juxtaposed, so that by a single observation, taken simultaneously in effect from two different viewpoints, the angle of parallax of a distant object can be measured by some suitable optical micrometric device, operated to bring about coincidence of the two images of that object, and thus determine its distance. The present paper deals systematically with various types of rangefinders. A simple account is first given of the geometry of range-finding, and then the following features are dealt with in succession: (1) Aligning power of the eye; (2) Fundamental range-finding equations; (3) End reflectors; (4) Separating prism systems; (5) Deflecting systems; (6) Infinity adjustment; (7) Halving adjustment; (8) Astigmatisers. Several diagrams are given illustrative of the various points dealt with. A. W.

51. *Reflective Power of Pigments in the Ultra-violet.* **C. Cochrane.** (Roy. Soc. Edinburgh, Proc. 35. pp. 146–152, 1914–1915.)—Former investigations have been confined to a single region of the ultra-violet spectrum. In the work here described the reflective powers of 33 pigments (oil-colours) were examined for the wave-lengths 2400, 2740, 3220, 3880, 4450 Å.U. The final method adopted was to cast the spectrum of an iron arc, formed by the aid of a Cornu's prism and quartz lenses, upon the pigment and upon a comparison piece of white cardboard. Photographs were taken by the light diffusely reflected and the images of pigment and cardboard compared, as it was shown that the white cardboard has a more or less constant reflective power for all the wave-lengths used.

There is evidence of selective reflection on the part of many of the pigments in the extreme ultra-violet. Though the essential chemical constituents of pigments may be the same, yet in many cases they behave differently as regards reflecting power. No attempt can yet be made to interpret the results in the light of chemical constitution, and it is unlikely that the problem will be any simpler than that of absorption spectra. T. H.

52. *Normal and Abnormal Dispersion in the Region of Long Wave-lengths.* **H. Rubens.** (Deutsch. Phys. Gesell., Verh. 17. 16. pp. 315–335, Aug. 30, 1915.)—Experimental determinations of the reflecting power of a number of solids and liquids for residual rays from various substances have been made. The results are tabulated, and a discussion is given of the bearing of these results on the dispersion in the long-wave region. Debye's theory of the molecular dipole is also dealt with, experimental determinations being made of the variation of reflecting power with temperature. A. W.

53. *Propagation of Light through an Inhomogeneous Medium.* **R. Gans.** (Ann. d. Physik, 47. 6. pp. 709–736, Aug. 17, 1915.)—A mathematical treatment which leads to the following results:—(1) In an inhomogeneous medium, of continuously varying index of refraction, light is propagated without reflection, though of course total reflection may occur. (2) The laws

of geometrical optics as to the direction of the rays are usually valid, except in the neighbourhood of the plane at which total reflection occurs. Here the angle of incidence is less than corresponds to Snell's law of refraction.

E. H. B.

54. *Intermittent Vision.* **C. V. Raman.** (Phil. Mag. 30. pp. 701–702, Nov., 1915.)—In a recent paper [Abs. 648 (1914)] Mallock brought forward the hypothesis that a slight mechanical shock to the head or body of the observer produces a periodic but rapidly extinguished paralysis of the perception of sight, and that the nerves on which seeing depends cannot bear more than a certain amount of mechanical acceleration without loss of sensibility. Later [Abs. 1670 (1914)] S. P. Thompson criticised Mallock's conclusions, stating that Mallock's hypothesis is unnecessary, and suggesting that retinal fatigue is the cause of the effect. The author of the present paper considers that Thompson's suggestion is also untenable, and brings forward the following explanation :—So long as the retina is absolutely at rest, and the white and dark sectors on the revolving disc follow one another at intervals short compared with the period of persistence of vision, the disc appears uniformly illuminated. But if the retina is set in motion even for a small fraction of a second, say by a slight mechanical shock, or by the eye involuntarily following the motion of the sectors, and if the direction of this motion is such that the white sectors remain on any given portion of the retina for a longer interval than they otherwise would, the impression of light over the areas occupied by the dark sectors has time enough to die away appreciably, and we thus get the illusion of stationary white sectors on a dark ground. A movement of the retina in the opposite direction should, however, produce little or no perceptible effect, provided the rotation of the disc is sufficiently rapid. This is exactly what is found in experiment.

A. W.

55. *Impulsive Production of Wave Motion.* **L. Zehnder.** (Deutsch. Phys. Gesell., Verh. 17. 16. pp. 336–342, Aug. 30, 1915.)—A theoretical discussion of the production of wave motion by impulse, with special reference to the action of a space grating subjected to Röntgen rays. A. W.

56. *Resolving Power of Interferometers.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 214–220, Oct., 1915.)—Discusses in some detail the resolving power of various instruments having high resolving power, and advocates the employment of crossed systems in preference to making attempts to increase the resolving power of individual instruments. Attention is paid to the question of the resolution of a strong line accompanied, as is often the case, by a much weaker satellite. A. W.

57. *Nickelled Glass Mirrors for Ultra-violet Photography.* **R. W. Wood.** (Astrophys. J. 42. pp. 365–369, Nov., 1915.)—For certain investigations it is necessary to avoid the usual silver-on-glass mirrors used in astronomical photography, as the silver transmits ultra-violet light, and a surface coating of nickel has been found to be satisfactory if it can be deposited in a uniform thick film on the glass surface. Recent improvements in the process of nickel deposition have been published by Hollard [Abs. 1783 (1912)], recommending the use of a solution of nickel fluoborate, and these have been employed by Wood with great success. He describes in detail the method of manipulation in coating with nickel a glass mirror of 55 ft. focal length by electro-deposition on a subsidiary silver film deposited chemically. A current of about 5·6 amps. was employed, with the anode 8 cm. from the mirror surface. C. P. B.

58. *Measurement of Sharpness of Photographic Images.* **O. Tugman.** (Astrophys. J. 42. pp. 321–330, Nov., 1915.)—In the investigation of resolving power of various photographic plates an adaptation has been made of the Koch registering microphotometer, which eliminates visual observation by allowing of direct photographic records. Details are given of the additions to the instrument for the special purpose in view, with the results of preliminary calibration experiments to determine the accuracy obtainable. [See Abs. 1522 (1912); 1824 (1914).] C. P. B.

59. *Resolving Power of Photographic Plates.* **O. Tugman.** (Astrophys. J. 42. pp. 331–348, Nov., 1915. Phot. J. 5. pp. 292–302, Dec., 1915.)—The theoretical resolution of a photographic emulsion has been defined by Wadsworth as corresponding to four times the diam. of the silver grains, but this only applies to non-diffusing media, whereas all the vehicles used for photography introduce scatter to a considerable extent. The practical resolution obtainable has been investigated by Mees [Abs. 55 (1910)] who examined the photographic images of a finely ruled grating, the scattering with different exposures being determined by using a black wedge over an illuminated slit. The rate of spreading of a photographic image was shown by Scheiner to vary as the logarithm of the exposure. Goldberg also made a long investigation of the phenomenon for various types of emulsion. In the present work use has been made of an accurately cut nickel straight-edge placed in close contact with the emulsion surface, the spreading of the image being then measurable from the reading for the edge. All the plates were backed, and exposed to a parallel beam of monochromatic light. After exposure the plate was cut into two strips, and each developed for a different time. The densities were then measured with a Koch registering microphotometer [see preceding Abs.]. Cross-sections of the films were made, and the spreading measured at different depths from the surface. C. P. B.

60. *Artificial Illuminants for Photography.* **K. Mees.** (Frank. Inst., J. 180. pp. 481–482, Oct., 1915.)—The author recommends the following illuminants :—*For portraiture:* Flame arcs, Cooper Hewitt lamps, gas-filled tungsten lamps. *For kinematograph work:* Cooper Hewitt, quartz-tube mercury lamp, and flame arc. *For photo-engraving:* enclosed arc, flame arc. *For silver printing:* enclosed or flame arcs. *For platinum printing:* Cooper-Hewitt lamp.

Photographic efficiency depends on sensitiveness of materials used. Thus there are (1) panchromatic materials sensitive to the whole spectrum and used with filters to give a rendering similar to that seen by the eye, or for colour-photography; (2) ordinary materials having max. sensitiveness in the blue-violet; (3) materials sensitive only to ultra-violet light. For panchromatic work the value of an illuminant depends entirely on its luminous efficiency. For other materials light of short wave-length is chiefly desirable, being favourable to latitude and freedom from halation. J. S. D.

61. *Photographic Efficiency of Illuminants.* **L. A. Jones, M. B. Hodgson,** and **K. Huse.** (Frank. Inst., J. 180. pp. 484–487, Oct., 1915. Abstract.)—The authors tabulate the photographic efficiency of various illuminants on ordinary, orthochromatic, and panchromatic plates, the results being arranged

in two ways, (*a*) showing the relative photographic efficiency for a fixed value of *the illumination*, and (*b*) showing the relative photographic efficiency from the standpoint of *energy consumption*. These data are tabulated as follows :—

SOURCE.	VISUAL EFFICIENCY, LUMENS PER WATT.	PHOTOGRAPHIC EFFICIENCY.					
		(*a*).			(*b*).		
		Ordinary Plate.	Orthochromatic Plate.	Panchromatic Plate.	Ordinary Plate.	Orthochromatic Plate.	Panchromatic Plate.
1. Sun	150	100	100	100	100	100	100
2. Sky	—	181	155	130	—	—	—
3. Acetylene	0·7	30	44	52	0·14	0·21	0·24
4. Acetylene (screened)	0·07	81	85	89	0·037	0·040	0·042
5. Pentane	0·45	18	28	42	0·053	0·086	0·13
6. Mercury arc—quartz	40	600	500	367	158	132	99
7. Mercury arc—"Nultra" glass	35	218	195	165	50	46	39
8. Mercury arc—Crown glass	37	324	275	249	79	68	62
9. Carbon arc, ordinary	12	126	112	104	10	9	8·5
10. Carbon arc white flame	29	257	234	215	52	45	2
11. Carbon arc, enclosed	9	175	177	165	11	11	10
12. Carbon arc, "Artisto"	12	796	1070	744	62	86	60
13. Magnetite arc	18	106	115	82	12	14	10
14. Carbon glow-lamp	2·44	23	32	42	0·37	0·52	0·68
Carbon glow-lamp	3·16	25	35	45	0·51	0·74	0·95
15. Tungsten vacuum lamp	8·0	33	41	50	1·74	2·2	2·7
Tungsten vacuum lamp	9·9	37	45	53	2·41	3·0	3·5
16. Tungsten nitrogen lamp	16·6	56	62	70	6·1	6·8	7·7
Tungsten nitrogen lamp	21·6	64	68	76	8·9	9·8	11·0
17. Tungsten blue bulb	8·9	—	—	—	5·5	5·2	5·6
Tungsten blue bulb	11	108	99	106	7·8	73	7·9
18. Mercury arc (Cooper Hewitt)	23	316	354	273	47	54·2	42

J. S. D.

62. *Use of Thermopile for Physical Photometry.* **H. E. Ives** and **E. F. Kingsbury.** (Phys. Rev. 6. pp. 319–333, Nov., 1915.)—It is found possible to use a thermopile as a physical photometer by employing a solution filter consisting of 60 gm. $CuCl_2$, 14·5 gm. $Co(NH_4)_2(SO_4)_2$, 19 gm. K_2CrO_4, 18 cm.^{3} HNO_3 (sp. gr. 1·05) made up to 1 litre with water. This solution was arrived at by trial with the spectrophotometer, and conforms quite closely to the luminosity curve determined by Ives. The thermopile used was a linear one with 18 Bi-Ag junctions in series, while the galvanometer was of the d'Arsonval type of a sensitivity of 33 mm. per microvolt. Between the filter and the lamp to be measured it is necessary to insert a water tank at least 2 cm. thick, in order both to keep the surroundings of the thermopile from unnecessary heating and also to provide a complete obstruction to any infra-red radiation, there being an infra-red transmission band in the filter solution. It is found that with this apparatus candle-powers as low as 8 can be measured accurately. The chief sources of error are (i) mechanical disturbance, (ii) drift of the galvanometer-thermopile system amounting sometimes to several per cent. of the reading during the time taken for a deflection and return to zero, and (iii) lack of exact proportionality between stimulus and

deflection. With proper precautions, however, the authors find no difficulty in attaining an accuracy better than 1 %. A further result of the present investigation is to show that there is an infra-red transmission band in the luminosity curve of the solution used previously for the determination of the mechanical equivalent of light [see Abs. 888 (1915)], and to indicate a corrected value for the lumen of 0·0059 watt. J. W. T. W.

63. *Variation of Hefner Lamp with Atmospheric Conditions.* **E. Ott.** (J. of Gas Lighting, 132. pp. 378–381, Nov. 16, 1915. Electrician, 76. pp. 227–230, Nov. 19, 1915. Communicated by the International Photometric Commission.)—There have been many different formulæ proposed to express the variation in candle-power of the Hefner lamp with change of atmospheric conditions. The author has made a fresh determination in a closed receiver, the pressure being varied from 816 to 614·5 mm. In the experiments on the effect of aqueous vapour and CO_2, the measurements of these quantities made by the Assman hygrometer and the Haldane apparatus [Abs. 1885 (1911)] respectively were found to be identical with those given by the gravimetric method. The new formula for the candle-power of the Hefner flame is $[y = 1{\cdot}049 - 0{\cdot}0062x - 0{\cdot}33\,(x' - 0{\cdot}75) + 0{\cdot}00011\,(b - 760)]$ in which x represents the volume, expressed in litres, which the aqueous vapour associated with 1 $m.^3$ of dry air free from CO_2 would have at the same temperature and pressure; x' is the CO_2 content similarly expressed; while b is the barometric pressure within the range 717 to 816 mm. Of these coefficients, that for x' differs considerably from Liebenthal's value, while that for x agrees with the determinations of previous observers [*loc. cit.* and Abs. 529B (1907)]. J. W. T. W.

64. *Thiele's Phase in Band Spectra.* **H. S. Uhler.** (Astrophys. J. 42. pp. 72–91, July, 1915.)—In the evaluation of the "phase" c in Thiele's series formula for band spectra, $\lambda = f[(n + c)^2]$, it is shown that the older methods of calculation are too complicated for practical purposes, and a new method for determining its value at different places along a band is developed, and illustrated by examples taken from measures of band spectra on high-dispersion photographs. Contrary to Thiele's view, the phase c is shown to be variable for the α and δ series of the λ5165 carbon band, and the two series starting from the first head of the λ3883 cyanogen band are shown to be unrelated according to the scheme of combination proposed by Thiele.

Evidence is presented suggesting that other of his hypotheses are invalid.

C. P. B.

65. *Comparisons of Wave-lengths by Interference Methods, and some Wave-lengths in the Spectrum of Neon.* **W. F. Meggers.** (Bureau of Standards, Bull. 12. pp. 198–205, 1915.)—In the process of determining secondary wave-length standards in the iron spectrum [see Abs. 68 (1916)], it was necessary to redetermine the corrections due to change of phase at reflection from the nickelled-quartz interferometer plates. Buisson and Fabry used the identical plates some years ago [Abs. 775 (1908)] and found these corrections to be an inverse linear function of the wave-length [Abs. 1409 (1908)]. Another method was employed in the present work, a description of which is here given. A neon fused-quartz vacuum tube was used as a source of light. These tubes have flat circular Al electrodes sealed in at the ends and are extremely efficient. One tube has been used for over 25 hours at high intensity, and shows no signs of electrode disintegration or gas occlusion. The error due to the phase-change at reflection can be corrected for each

wave-length directly from its measured values obtained from thick and thin étalons. The determination of this correction is illustrated by some measurements of wave-lengths in the spectrum of neon. The values of 10 lines from λ3369 to λ3520 and seven from λ6506 to λ7032 are given. An example is added to show how the determination of the exact order of interference, or the optical measurement of length can be made easily and rapidly with the aid of certain wave-lengths of neon radiation. A. W.

66. *Energy Distribution in Spectrum of Carbon and Mercury Arcs and of the Sun.* **E. S. Johansen.** (Strahlentherapie, 6. pp. 45–63, 1915.)—The energy measurements in the experiments here described were made partly with a vacuum bolometer and partly with a vacuum thermo-element, used with a Jaeger galvanometer. A Fuess spectrometer was used for determining the wave-length of the rays under investigation. The chief interest of the paper is in the diagrams showing the energy distribution in the different light-sources used. The curve for the Finsen-Reyn lamp shows bands at 0·46 μ, 0·42 μ, 0·388 μ, 0·359 μ, and 0·25 μ, that at 0·388 μ being very marked. A band in the ultra-red is attributed to water-vapour absorption. Curves are also given for an ordinary d.c. carbon arc, for the Kromayer mercury lamp, and for the sun's spectrum, the zenith distances for the latter being 30° and 60° at Mount Whitney, and 30°, 60°, and 75·5° at Washington. The sun curves have been obtained from the data of Abbot. A. W.

67. *Distribution of Light Emission in the Arc and Spark.* **J. Kramsztyk.** (Ann. d. Physik, 48. 3. pp. 375–409, Oct. 29, 1915.)—Describes research, on similar lines to those followed by Lenard, upon the special distribution of various spectrum lines in the different parts of the electric arc and spark. The spectra of the alkalies and of the alkaline earths were investigated, and also those of Ag, Cu, Zn, Al, and Mg. It was found that in the case of all the metals dealt with, different "layers" of the arc give rise to different sets of lines, and the lines emitted by a single layer are found to belong to the same series. Similar layer effects were observed in the spark spectra, and comparison of the arc and spark results showed that corresponding lines were emitted by corresponding layers. Two new lines were found in the spectrum of copper, and it is shown that there are in this spectrum three pairs of lines, with the constant frequency-difference 30, both in the arc and spark. The two new lines λ5545 and λ5399 are each a component of one of these three pairs, the other four lines having previously been observed by Aretz. The method adopted in the experiments should prove a useful one for investigating spectral series. A. W.

68. *Interference Measurements of Wave-lengths in the Iron Spectrum.* **K. Burns.** (Bureau of Standards, Bull. 12. pp. 179–197, 1915.)—Between the limits λ2851 and λ3701, 181 wave-lengths have been measured in conformity with the recommendations of the International Wave-length Committee. Where it was found possible faint lines as well as strong ones were measured. Throughout the greater part of the region λ2987 to λ3701 lines were measured at intervals of 10 Å. units or less. The spectroscope used was a 2-ft. grating, mounted in parallel light, and the étalon was 3·75 mm. thick. The method was that of Buisson and Fabry. The mean difference between the present observations and the I.Å. standards is one part in two million; the systematic difference is half of that. Between λ2851 and λ3300, where there are no I.Å. standards, a comparison with the work of Buisson and Fabry shows a

systematic difference of one part in a million; allowing for the systematic difference there is a mean difference of one part in three million. The systematic difference Burns — Pfund is + 0·001 Å. unit; the mean difference is ± 0·0018 Å. unit in the region of wave-lengths shorter than 8800. Comparisons with different series of grating measurements confirm the belief, which is gaining ground, that secondary standards are needed at much closer intervals than was at first supposed. [See also Abs. 550 (1915).]

A. W.

69. *Temperature Variations of Cobalt and Nickel Furnace Spectra.* **A. S. King.** (Mt. Wilson Solar Observatory, Contrib. No. 108. Astrophys. J. 42. pp. 344–364, Nov., 1915.)—A discussion is given of the variations of intensity with temperature of the spectrum lines of Co and Ni volatilised in a carbon-tube electric furnace. As with similar work on other metals [Abs. 54, 690 (1915)] the lines are classified into groups according to the temperature at which they first appear and their rate of increase as the temperature rises. The apparatus was the 15-ft. vertical concave spectrograph, using the second order giving a dispersion of 1 mm. = 1·85 Å. as far as λ5200; after that the first order to λ6700. Three temperatures were adopted, 2000–2100°, 2300°, and 2500–2600° C., recorded by a Wanner pyrometer. Purified specimens of the metals were used (Kahlbaum), and as the carbon tubes were of regraphitised Acheson graphite, there was little trouble with impurity lines. Details are tabulated for all lines shown between λ2982 and λ7122. A number of lines, especially of Co, which have been classified as enhanced, appear in the furnace spectra, thus indicating that they may not be of pronounced enhanced type. In general, compared with the spectrum of the arc, the furnace spectrum is relatively richer in violet lines.

C. P. B.

70. *Crossed Spectra obtained by Different Combinations of Interferometers.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 220–228, Oct., 1915.)—In order that spectral lines may be studied without ambiguity it is necessary to employ combinations of interferometers, as thereby "ghosts" may be eliminated. The only instrument which is almost free from ghosts is the Fabry-Perot interferometer, which has the further advantage that its resolving power can be varied within a very wide range. The problem to be solved in connection with the combinations of interferometers is to find out in what curve the interference points are arranged, as the wave-length is continuously varied within narrow limits. Such as fall outside the curve can be recognised as ghosts, as shown by Gehrcke and v. Baeyer. The present paper gives a concise account of various combinations. The combinations dealt with are (i) Echelon and Lummer-Gehrcke plate, (ii) Two Lummer-Gehrcke plates, (iii) Two echelons, (iv) Echelon with Fabry-Perot interferometer, (v) Lummer-Gehrcke plate and Fabry-Perot interferometer, (vi) Two Fabry-Perot interferometers. The curves for the interference points are dealt with in each case, and other possible combinations are suggested as being likely to prove useful in certain cases. [See Abs. 77 (1914).]

A. W.

71. *Interference of Crossed Spectra and Trains of Beating Light-waves.* **C. Barus.** (Am. J. Sci. 40. pp. 486–498, Nov., 1915.)—If two component spectra from the same source coincide throughout their extent, the elliptic interferences will be spread over the whole surface, provided the respective glass and air path-differences of the component rays are not too great to interfere with visibility. If now one of the spectra be rotated 180° around a longi-

tudinal axis, parallel to the red-violet length of the spectrum and normal to the Fraunhofer lines, interference should be possible only along the infinitely thin longitudinal axis of rotation, but interference has been observed along a definite longitudinal band in the spectrum, about twice the angular width of the distance between the sodium lines, and symmetrical with respect to the axis of rotation. It is independent of the width of the slit, provided this is narrow. Again, let one spectrum be rotated 180° about a given Fraunhofer line, the mean D-line, for instance. The two coplanar spectra are now mutually reversed, and interference should take place only along the D line and be again inappreciable. The phenomenon, however, has been observed appearing as a single line, vividly coloured above the brightness of the spectrum; or again more jet-black than the Fraunhofer lines and located in the position of the coincident wave-lengths of the two superimposed spectra. It is possible, however, to obtain two spectra in such a way that if their longitudinal axes coincide the Fraunhofer lines intersect at a small angle, and *vice versa*. In such a case for coincident lines, interference occurs in a band around these lines and is absent in the rest of the spectrum; whereas, if the longitudinal axes are coincident, the interferences are arranged with reference to these axes. Full details are given of the experiments. Discussion of the results leads to the conclusion (longitudinal axes coinciding) that distinct and independent points of the narrow slit whose distance apart along its length is not greater than 0·1 mm., are capable of producing interference in each of the colours of the spectrum. Again, in the case of rotation of one spectrum about a transverse axis, colours which differ in wave-length by less than half the distance apart of the two Na lines also admit of interference. This permissible difference is thus relatively about $\Delta\lambda/\lambda = 5 \times 10^{-4}$, or less than 0·1 %. The character of these interferences is distinctive. They are not of the regular elliptic type, but in form resemble a succession of long spindles or needle-shaped designs. The chief peculiarity is observed in their almost scintillating mobility, which is ascribed to inevitable tremors of the laboratory. These results introduce the question of beating wave-trains, which is discussed in the light of the experiments. Further experiments in connection with this subject are in progress. A. W.

72. *Widening of Spectrum Lines by the Doppler-effect.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 237–243, Oct., 1915.)—A discussion of the subject has recently been given by Rayleigh [Abs. 555 (1915)]. The present paper gives measurements of the widening obtained from the width of the dots in photograms with a Fabry-Perot interferometer in which the air interspace had been increased to 8 or 9 cm., the widening to be attributed to the finite resolving power being thus insignificant, as the resolving power is over two million for both the green and violet mercury lines. From the results a calculation of the limiting order of interference could be made for the two lines studied. The numbers obtained were 750,000 for the green line and 810,000 for the violet line. The value found by Perot and Fabry for the green line was 790,000, which is in good agreement considering the difficulties of measurement. A. W.

73. *Fine Structure of Mercury Lines.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 229–237, Oct., 1915.)—Preliminary measurements of the fine structure of Hg lines have already been published [Abs. 556 (1915)]. Details are now given of the results obtained for various Hg lines. The line λ5461 was examined by combining a Lummer-Gehrcke plate with a Fabry-

Perot interferometer. It was found that the principal line is a triplet with a strong satellite on the negative side and a weak one towards the red. The principal line of the violet line λ4859 is also a triplet, of which the middle component is rather weak compared with the side components, each of which is associated with a strong satellite. The principal line of λ4047 shows the same character, consisting of a triplet having a satellite on each side. Hence all these three lines are similar, and as they belong to the second subordinate series the distribution of the satellites is probably characteristic of the series. The principal line of λ4078 has three almost equidistant attendant satellites, whose intensities gradually diminish on receding from the principal line. The triplet is here apparently missing, though the line belongs to the same series. Photographs were taken of the lines λ5769 and λ5790. These, owing to the long exposures necessary, were not very distinct. On one or two plates, however, were traces showing that λ5769 consists of three, and λ5790 of five components. This, however, will require confirmation. A. W.

74. *Width of Spectrum Lines.* **A. Landé.** (Phys. Zeits. 16. pp. 313–316, Sept. 15, 1915.)—A mathematical treatment of the broadening of lines obtained by means of a grating. [See also Abs. 1250 (1915.)] A. W.

75. *New Fluorescence Spectrum of Uranyl Ammonium Chloride.* **E. L. Nichols** and **E. Merritt.** (Phys. Rev. 6. pp. 358–376, Nov., 1915.)—Triclinic plates, with the composition $UO_2Cl_2 . 2NH_4Cl . 2H_2O$, have been prepared which exhibit a strong fluorescent spectrum which, unlike that of other uranyl compounds, is resolved at ordinary temperatures into at least 8 groups consisting of 5 nearly equidistant bands. The band groups correspond to the single bands of the ordinary uranyl fluorescence spectrum. The new spectrum is characterised by its remarkable symmetry; not only are the distances ($1/\lambda \times 10^3$) between the centres of the groups the same, but this holds also for the intervals between homologous bands. There is, however, in the distances between neighbouring bands in any one group a slight progressive diminution as we pass towards the violet. The authors have also made measurements of the intensities of the bands, and of the shifts and changes produced on lowering the temperature to − 185° C.

The absorption spectrum of the crystals is equally symmetrical, but the constant frequency interval is somewhat smaller. The absorption bands are approximately coincident with the bands found by Jones and Strong for the simple chloride in solution. C. S. G.

76. *Spectrum of X-rays.* **B. Cabrera.** (Nature, 96. p. 144, Oct. 7, 1915.)—Kossel [see Abs. 1674 (1915)], discussing the previous measurements of the frequencies of the corresponding lines of the spectrum K and L characteristic for different elements, established certain numerical relations which Wagner [Abs. 1269 (1915)] confirmed. In addition, the precise measurements of Bragg and Pierce [Abs. 75 (1915)] for the lines K_α, K_β, K_γ in Ag, Pd, and Rh give additional confirmation. Using Kossel's modification of Bohr's model for the atom, and collecting the experimental results of Moseley, Rutherford, and Andrade, the author illustrates clearly the excellent agreement between the values of the characteristic frequency ν for several elements as calculated by the two entirely distinct methods indicated. The increasingly complex nature of spectra as we proceed from X-rays to visible light rays is also discussed. A. B. W.

77. *Coefficients of Absorption of the Constituents of a Beam of Heterogeneous Röntgen Rays; and Coefficient of Damping of a Vibrating Dynamical System.* **J. J. Thomson.** (Phil. Mag. 30. pp. 780–783, Dec., 1915.)—A mathematical paper dealing with a method of finding the absorption coefficients of the constituents of a complex beam of X-rays. In such a case the intensity of the rays after passing through a thickness *d* of aluminium can be represented by the expression $A_1e^{-\lambda_1 d} + A_2e^{-\lambda_2 d} + A_3e^{-\lambda_3 d} \ldots A_ne^{-\lambda_n d}$; the problem is to find from the 2_n necessary observations the values of $A_1\ A_2 \ldots A_n$; $\lambda_1, \lambda_2, \ldots \lambda_n$. Though the author arrived at the method from the consideration of the absorption problem, it is shown to be of much more general application, and applies to any quantity which can be represented as the sum of a series of exponentials of some variable, whether the coefficients of the exponent are real, imaginary, or complex. The cases of damped and undamped vibrations are considered mathematically on this basis. A. B. W.

78. *Recoil of Radium D from Radium C.* **A. B. Wood** and **W. Makower.** (Phil. Mag. 30. pp. 811–815, Dec., 1915.)—Many attempts have been made to detect the photographic action of the recoil stream emitted by radio-active surfaces [see Abs. 461 (1915)], but hitherto they have been unsuccessful in detecting any *direct* action. It seemed possible that the failure to procure any direct photographic evidence of the recoil stream might be due to the extreme facility with which this type of radiation is absorbed by matter; for an ordinary photographic plate contains so much gelatin that most of the recoil particles striking the plate are absorbed by the gelatin before colliding with a grain of silver halide. In order to overcome this difficulty experiments were made by Wood and Steven [Abs. 861 (1915)] to obtain the effect by means of Schumann plates, using polonium as the source of the recoil stream. These experiments were unsuccessful, however, for several reasons mentioned [*op. cit.*].

In the present experiments the authors describe a successful attempt to obtain this photographic action of recoil particles, using an extremely active source of RaC (by exposing a Pt-wire to 800 millicuries of RaEm in a fine capillary tube). A reproduction of one of the photographs is shown in illustration. A. B. W.

79. *Velocity of Electrons expelled by X-rays.* **C. G. Barkla** and **G. Shearer.** (Phil. Mag. 30. pp. 745–753, Dec., 1915.)—If the electrons in the corpuscular radiation from substances exposed to X-radiation were ejected under the same conditions as those ejected by ultra-violet light, the experiments of A. L. Hughes [see Abs. 1874 (1912)] would suggest that there would exist well-marked differences in the velocities from various substances. Careful investigation of this question by the authors has shown that these differences do not exist. The max. velocity of ejection does not depend upon the particular substance from which the electron is ejected. (Possible error 1 to 2 %.) It is shown that the Ionisation-Pressure curves for ionisation by K and L corpuscular radiations are identical. The K and L electrons from a particular substance under the action of X-rays, although those electrons are different in origin and in association, are emitted with approximately the same velocity. A. B. W.

HEAT.

80. *Thermal Conductivity of Refractories.* **B. Dudley, Jr.** (Am. Electrochem. Soc., Trans. 27. pp. 285–328; Disc., 328–337, 1915. Met. and Chem. Eng. 13. pp. 315–316, May, 1915.)—The method employed by the author consists in heating a wall of the "brick" being tested with a specially constructed coke-fired furnace, and measuring the rate of heat flow through a certain area of the wall by means of a water-jacket applied to the cold side. Temperature measurements (by Pt-Pt-Rh couples) are made at various points in the brick, and from the data thus secured the conductivity of the material of the wall is calculated. The advantages claimed in the method are that special shapes of the substance are unnecessary, and the conductivity is readily calculated without recourse to complicated factors involving the shape of the conducting body. From measurements of the temperature slope in the brick (of thickness 9 in.) the author calculates the conductivity at various temperatures up to 1000° C. The equations of the temperature gradients are determined on the assumption that the curves are parabolas, of general form $t^2 + nt + nx + p = 0$. The conductivity (k_t) at any temperature $t°$ are then obtained from the general equation, $k_t = (\mathrm{H/A})/(dt/dx)$, where $dt/dx = -n/(2t + m)$.

The main results are given below (in gm. cals. per sec. per inch-cube per degree C.) :—

Material.	Average "k" at 100° C.	Average "k" at 1000° C.
Woodland	0·0043	0·0086
Quartzite	0·0051	0·0086
Star silica......................	0·0056	0·0108

In the *discussion*: **C. Hering** noted that the surface resistance, which may be very considerable, was not measured; also that the conductivities at higher temperatures were obtained by extrapolation. **J. W. Richards** translated the results into the form: Conductivity as a constant at 0° C. + a function of the temperature; also in calories per cm.-cube, so that $\mathrm{K}_t = \alpha + 2\beta_t$. The mean conductivity from 0° to $t°$ C. is then $\mathrm{K}_m = \alpha + \beta_t$; and that between any two temperatures t' and t'' is $\mathrm{K}_m = \alpha + \beta(t' + t'')$.

	α.		β.	
	Cals. per in.-cube.	Cals. per cm.-cube.	Cals. per in.-cube.	Cals. per cm.-cube.
Woodland brick	0·0038	0·0015	0·0000024	0·0000010
Quartzite	0·0047	0·0019	0·000000195	0·0000008
Star silica	0·0050	0·0020	0·0000029	0·0000016

T. B.

81. *An Aneroid Calorimeter.* **H. C. Dickinson** and **N. S. Osborne.** (Bureau of Standards, Bull. 12. pp. 23–48, 1915.)—The calorimeter consists of a cylindrical copper vessel, in the walls of which are embedded a heating coil and a Pt-thermometer, thus differing from somewhat similar instruments by Eucken [Abs. 1714 (1909)] and others. The calorimeter is fitted with a cooling system (carbon dioxide compression) and a heating element, and these, in connection with an ingenious thermostatic appliance, can maintain any desired temperature between − 55° and + 40° C. within a few thousandths of a degree. Differences in temperature between the surface of the calorimeter and that of the jacket are kept very small, and are accurately measured by means of multiple thermo-couples having 10 junctions distributed over the surface of each. It is claimed that, with the same instrument, measurements can be made from the lowest attainable temperature up to 200° C. or higher, and it can be used for both solids and liquids even under high pressure. Determinations can be obtained within very small intervals of temperature, and troublesome corrections due to evaporation of liquid and to energy supplied by a stirring device are eliminated.

Results of measurements of the specific heat of water in the range 0° to 40° C. are given, and an accompanying curve shows a minimum at a temperature of about 32° C., with no discontinuity in the neighbourhood of 0° C., where the results of previous observers have been discordant. These results agree well with a large number of unpublished measurements obtained in the same laboratory by means of the usual form of stirred calorimeter. The apparatus has been used for a variety of problems, including the specific heat and latent heat of fusion of ice [see Abs. 1547 (1915)].

T. B.

82. *New Method for determining the Specific Heats of Liquids.* **E. J. Hartung.** (Faraday Soc., Trans. 11. pp. 64–68, Oct., 1915.)—The method consists in introducing into a known weight of the liquid, a sealed glass bulb containing a known weight of ice at a known temperature. The details of the apparatus and method of working are given. The following results of the specific-heat determinations between 17° and 20°, were obtained:—Methyl alcohol, 0·591; ethyl alcohol, 0·564; ethyl ether, 0·541; carbon disulphide, 0·234; aniline, 0·472; nitrobenzene, 0·342. A. F.

83. *The Variation of the Specific Heat of Solids with Temperature.* **A. H. Compton.** (Phys. Rev. 6. pp. 377–389, Nov., 1915.)—A theoretical paper containing a quantitative explanation of the variation of the specific heat of solids with temperature, at very low temperatures, which does not involve the conception of energy quanta. The investigation is based on the assumption that, if the relative energy between two neighbouring atoms in a solid falls below a certain critical value (ϵ), the two atoms become agglomerated so that the degree of freedom between them vanishes, reappearing again as soon as the energy increases above the critical value. The author first writes the internal energy (U) of the atoms in a form involving P, the probability that a certain possible degree of freedom shall exist; P is then found from the above assumption by applying Maxwell's distribution law, so that U and consequently C_v, are determined. The value of C_v so obtained is $C_\infty \epsilon^{-\tau/T}(\tau/T+1)$, where $\tau = \epsilon/2R$; R being the gas constant for a single molecule, τ can be determined from the experimental values of C_v if C_∞ is known. Rayleigh gives $C_\infty = 3R$; but this, combined with the experimental values of C_v, makes the ratio C_v/C_∞ approach 1·02 as a limit at higher temperatures. Hence for the calculations in this paper C_{∞} is chosen so that the limiting value of the ratio is unity. The values of ϵ for a number of different substances can thus be calculated and it is found that it is equal to $5{\cdot}44 \times 10^{-27}\ \nu$ erg; ν being taken from Nernst and Lindemann's results. Thus ϵ is very nearly equal to Planck's quantum.

The last part of the paper is devoted to a critical discussion of the theory of Debye's expression for C_v. It is shown that his equation must be considered to be largely empirical; so that Einstein's expression should be taken as the true result of the quantum theory. It is claimed that the new expression for the specific heats agrees better with the experimental results than that obtained by Debye and much better than that due to Einstein.

D. O. W.

84. *Change of Specific Heat of Gases with Temperature.* **W. M. Thornton.** (Electrician, 75. pp. 948–949, Oct. 1, 1915. Paper read before the British Assoc. at Manchester.)—The first report of the Gaseous Explosions Committee [B. A. Report, p. 308, 1908, and Abs. 1156B (1908)] contains a discussion of experimental work on specific heats. It is there divided into three classes: (1) Constant pressure experiments; (2) Constant volume experiments, (*a*) Direct determination with steam calorimeter, (*b*) Explosions; (3) Experiments in which both volume and pressure are varied. In every case the effective specific heats are found to increase with rise of temperature. Values of the "molecular" specific heats, taken from a discussion by Lewis and Randall [see Abs. 1849 (1912)], are given.

A cause of this increase of specific heat with rise of temperature has been referred to by Callendar [*op. cit.*] with special reference to radiation. It is now shown by the author that another cause, which may play an important part even in steady-flow experiments, at moderate temperatures, is to be found in the obvious mechanical fact that when moving bodies adhere and spin round their common centre of mass there is loss of translational energy of the whole. A gas in which this action is proceeding contains more energy available as heat than is indicated by its temperature. The specific heats will be therefore raised. T. B.

85. *Characteristics of Radiation Pyrometers.* **G. K. Burgess** and **P. D. Foote.** (Bureau of Standards, Bull. 12. pp. 91–178, 1915.)—The first part of this paper gives an account of the principles underlying the operation of total radiation pyrometers and describes some representative types. Some 20 instruments were examined in the course of the research, including the various forms of Féry, Foster, Thwing, and Brown pyrometers. A considerable portion of the paper is devoted to the examination of the sources of error met with, and to the description of methods of eliminating or correcting these. The principal errors noticed are shown to lie in the design and mechanical construction of the instruments themselves, and certain of these errors, such as lag, require that the pyrometer be calibrated under the same conditions of time of exposure, distance from, and aperture of source as will obtain in actual use. Other errors considered in the paper are stray reflection, convection currents, intervening atmosphere, size of source, and tarnishing of receiving mirror. Through this last effect errors of more than 100 deg. C. may readily be introduced. Further, it is shown that the errors due to varying the focusing distance may amount to several hundred degrees unless suitable precautions are taken. The error introduced by the selectivity of the gold mirror of a Féry pyrometer does not

become appreciable until above 2500° C., but may cause an error of 500° C. at sun temperature.

In general, radiation pyrometers behave as "grey" receivers and obey a law similar to the Stefan-Boltzmann law, viz. $E = aT^b$, where b is a constant slightly different from 4 and varying with the particular pyrometer used. The value of b depends on the design of the instrument and is found to vary from 3·5 to 4·5 in the 20 pyrometers investigated. The same instrument of the Féry type may have a different exponent according as it is used with or without the sectored diaphragm. For the rapid comparison of different types of photometer and the determination of the effects of size of aperture and focusing distance a "comparison" radiator consisting of a nickel (oxide) strip electrically heated is employed. This is first calibrated against a black body and thereafter forms a convenient source of radiation for comparative measurements on the same type of instrument where its selectivity will not introduce any appreciable error, while its size and quickness in heating give it a great advantage over the ordinary black body. Finally, the application of the radiation pyrometer to the determination of the total emissivity of selective radiators and to the measurement of temperatures is briefly considered. J. W. T. W.

86. *Emissivity of Metals and Oxides.* II. *Measurements with the Micropyrometer.* **G. K. Burgess** and **R. G. Waltenberg.** (Bureau of Standards, Bull. 11. pp. 591–605, 1915.)—Part I of this work dealt with the emissivity of nickel oxide [see Abs. 473 (1915)]. The micropyrometer, an instrument for the determination of the monochromatic emissivities of metals, etc., in microscopic quantities, has already been described [Abs. 621 (1913)]. The authors now explain the use of the instrument for comparing the emissivity of a substance with that of Pt, where $e = 0{\cdot}33$ for $\lambda = 0{\cdot}650\,\mu$, and $e = 0{\cdot}38$ for $\lambda = 0{\cdot}547\,\mu$. The micropyrometer is brought alternately to the same brightness as a Pt strip and the surface whose emissivity is sought, the latter resting on the Pt strip as the temperature is raised. The apparent temperatures of the surfaces are then measured in succession. The emissivity E_λ is calculated from Wien's equation, $\log E_\lambda = c \log_{10} e/\lambda \,.\, 1/T - 1/S$, where $c = 14{,}450$, and T and S are the absolute true and equivalent temperatures of the substance. Measurements of emissivity with red and with green light have been made of 28 metals and 12 oxides. It is found that practically all the metals examined have a negligible temperature coefficient of emissivity from 20° C. to the melting-point. Nickel oxide, however, has a well-defined negative coefficient. There is a discontinuity in emissivity for $\lambda = 0{\cdot}65\,\mu$ for some of the metals, including Pt. This would tend to destroy the constancy of the Violle unit of light, which is based on the luminous radiation from Pt at its melting-point. T. B.

87. *Emissivity of Metals and Oxides.* IV. *Iron Oxide.* **G. K. Burgess** and **P. D. Foote.** (Bureau of Standards, Bull. 12. pp. 83–89, 1915.)—The object of the investigation is the determination of the monochromatic emissivity for a wave-length $\lambda = 0{\cdot}65\,\mu$, and the total emissivity of iron oxide formed by heating iron in air. [See preceding Abs. for former papers.] Several methods were tried, but the only one giving satisfactory results was that of the "microscopic melts." A small sample of the oxide is placed on a Ni or Pt strip heated electrically. Upon the oxide are placed minute pieces of sodium chloride, sodium sulphate, and gold. At the instant of melting of one of these substances the apparent temperature of the oxide surface is

observed by a Holborn-Kurlbaum optical pyrometer, employing light of wave-length $\lambda = 0{\cdot}65\,\mu$. The emissivity E_λ is given by Wien's equation. The total emissivity is determined by means of a Féry pyrometer. Iron oxide in the spectral region ($\lambda = 0{\cdot}65\,\mu$) is found to be almost "black," its emissivity ranging from 0·98 to 0·92 between temperatures 800° to 1200° C. The total emissivity increases from 0·85 to 800° C. to 0·89 at 1200° C., the values above 800° being obtained by extrapolation. The corrections necessary to apply to the readings of a radiation pyrometer in this temperature-range vary from 30° to 50° C. A large temperature gradient is found to exist through the oxide layer formed on the surface of iron tubes heated electrically in air. T. B.

88. *Incandescent Solids with Subnormal Infra-red Emission.* **W. W. Coblentz.** (El. World, 66. pp. 1155–1156, Nov. 20, 1915.)—It has been shown that solids can emit banded spectra [see Abs. 226 (1909)], and the author has found that a thin thread of a complex aluminium silicate supported by a rod of Al_2O_3 emits, when brought to a state of incandescence, light of a spectral distribution containing deep indentations in the infra-red. The natural result is a considerably enhanced radiant efficiency, relatively less energy being emitted in the invisible infra-red region than is the case with radiators having a normal spectral distribution. J. W. T. W.

89. *Isothermals of Monatomic Gases and of their Binary Mixtures.* XVII. *Isothermals of Neon and Preliminary Determinations concerning the Liquid Condition of Neon.* **H. K. Onnes** and **C. A. Crommelin.** (K. Akad. Amsterdam, Proc. 18. pp. 515–520, Oct. 30, 1915. Comm. No. 147*d* from the Phys. Lab., Leiden.)—This paper contains a first instalment of the isothermal determinations for neon, including those for 0° and 20° C. from 20–93 atmos. and 20–84 atmos. respectively, and parts of those for —182·6°, —200·1°, —208·1°, —213·1° and —217·5° C. The virial coefficients at 20° and 0° are calculated to be: A_A, 1·0731 and 0·199986; $B_A \times 10^3$, 0·51578 and 0·41334, and $C_A \times 10^6$, 0·82778 and 1·1538 respectively. The vapour pressures were determined directly as the pressures of a bath of liquid neon, the temperature of which was measured by a helium thermometer :—

Temperature.	Vapour Pressure in cm. of Mercury.	Density of the Liquid.
—245·68° C	81·62	—
—245·88	76·71	1·204
—245·92	76·00 (boiling point)	—
—246·66	60·52	—
—247·49	45·16	—
—248·51	32·50	1·248
—248·67	32·35 (triple point)	—

The pieces of isothermals at low temperatures are too short and have, therefore, too few characteristic features to yield the critical constants of neon by the method of drawing them in a logarithmic diagram and making this fit the diagram of another substance of known critical data by parallel motions in two directions. Definite results, although of only preliminary value, are however, obtainable by utilising in addition the value of the critical pressure, the net of isothermals of neon in a $pv/T - \log p$-diagram being placed on that for hydrogen, oxygen, or argon and the temperatures of coincident isothermals ascertained. The critical temperature of neon is thus found to be: from hydrogen, −231·2° and −233·2° C.; from oxygen, −230·9° C.; from argon, −227·9 to −228·2° C. T. H. P.

90. *Application of the Principle of Dynamical Similitude to Molecular Physics.* **W. B. Hardy.** (Roy. Soc., Proc. 92. pp. 82–100, Nov. 1, 1915.)—The principle of dynamical similitude is developed and applied to the case of the internal heat of evaporation. It is found that if temperature be proportional to the mean energy of progressive motion of the molecules, the internal latent heats of dynamically corresponding states should be given by the equation $LM = a\tau$, where L is the latent heat, M the gramme-molecular weight, a a constant, and τ the temperature. This equation may be used either to identify corresponding temperatures or to test some assumption as to corresponding temperatures. In this paper the assumption made is that the critical states are dynamically corresponding states, and that corresponding temperatures are equal fractions of the critical temperature. The equation for internal latent heats is then found to have the form $LM + b = a\tau$ for normal paraffins and for certain halogen derivatives of benzene. The conclusion is drawn that, subject to the assumption being correct, the potential energy of repulsive forces acting between the molecules contributes to the process of evaporation. An examination of the alternative view that corresponding temperatures may be identified by the relation $LM = a\tau$ is deferred for the present. A. F.

91. *Further Experiments with Liquid Helium.* XXV. *Determination of the Temperatures obtained with Liquid Helium, especially in connection with Measurements of the Vapour Pressure of Helium.* **H. K. Onnes** and **S. Weber.** (K. Akad. Amsterdam, Proc. 18. pp. 493–507, Oct. 30, 1915. Comm. No. 147*b* from the Phys. Lab., Leiden.)—The authors give the results of new determinations of the vapour pressure of helium, based on more accurate temperature measurements, together with a contribution to the knowledge of the correction for the thermal molecular pressure, which has to be applied with constant-volume thermometers for low temperatures with gas under diminished pressure if the manometer is kept at the ordinary temperature. The difficulties inherent in the determination of the lowest temperatures are discussed. Two thermometers, one provided with a mercury manometer and the other with a very small heated-wire manometer were used. The differences between the previous results [Abs. 509 (1912)] and those now obtained—see table below—are explainable by the correction for the thermal molecular pressure:—

Temperature.	Vapour Pressure, mm. Hg.	Temperature.	Vapour Pressure, mm. Hg.
4·22° K.	767	5·10° K.	1569
4·91	1329	5·15	1668
5·05	1520	5·20 (crit.)	1718

These results cannot be represented by Nernst's vapour-pressure formula and appear to agree only very imperfectly with the Bose-Rankine formula containing four constants, $\log p = A + B/T + C/T^2 + D/T^3$. T. H. P.

92. *Isothermals for Air, Argon, and Helium.* **L. Holborn and H. Schultze.** (Ann. d. Physik, 47. 8. pp. 1089–1111, Sept. 14, 1915. Communication from the Physikal.-Techn. Reichsanstalt.)—Describes experimental determinations of the isothermals for air, argon, and helium between 0° and 200° C. The pressures were obtained by means of a pressure balance previously described [Abs. 1281 (1910)]. The results are tabulated and a discussion of them will be given in a subsequent paper. A. W.

93. *On von Babo's Law and Kirchhoff's Equation for the Latent Heat of Dilution.* **A. W. Porter.** (Faraday Soc., Trans. 11. pp. 19–28; Disc., 47–50, Oct., 1915.)—Three methods are given for deducing the latent heat of reversible dilution of a solution in terms of the vapour-pressures of solution and solvent, and the increase of volume s of the solution when 1 gm. of solvent is added to a large quantity of it. The more accurate expressions deduced in this way become identical with Kirchhoff's equation—

$$H = RT^2\, \partial/\partial T\,.\,\log(\pi_0/\pi)$$

when certain approximations are made, *e.g.* assuming that s is independent of the temperature and that the vapour follows the perfect gas law. A closer approximation can be obtained by assuming for the vapour the equation $v - b = RT/p - c$, where b is practically 1 c.cm. and c varies as the 10/3 power of the temperature. The physical meaning of Kirchhoff's equation is discussed, special attention being directed to the effects produced by hydration of the solvent and of association of the solute. T. M. L.

94. *Vapour Pressures of Sulphur Dioxide and Nitrous Oxide at Temperatures below their Normal Boiling-points.* **G. A. Burrell and I. W. Robertson.** (Am. Chem. Soc., J. 37. pp. 2691–2694, Dec., 1915.)—For sulphur dioxide the vapour pressure ranges from 760 mm. at —11·0° to 0·5 mm. at —94·4° and for nitrous oxide from 760 mm. at —88·7° to 1 mm. at —144·1°. The equations to the curves, calculated from the Nernst formula, $\log p = \lambda/4{\cdot}571\,T + 1{\cdot}75 \log T - \epsilon T/4{\cdot}571 + C$, are found to be: for liquid SO_2, $\log P = -1448{\cdot}01/T + 8{\cdot}425$, and for solid N_2O, $\log P = -1232{\cdot}2/T + 9{\cdot}579$. The average heats of evaporation over the temperature range studied, calculated by means of the Clausius-Clapeyron equation, are 6619 and 5632 cals. per gm.-mol. of liquid SO_2 and solid N_2O respectively. T. H. P.

95. *Probability Theorem and Radiation.* **M. v. Laue.** (Ann. d. Physik, 47. 7. pp. 853–878, Sept. 3, 1915.)—A highly analytical treatment as to the probability of the irregularities of the space distribution of point sources and of their radiation and an application to Planck's quantum theory of radiation. [Abs. 874 (1915).] E. H. B.

96. *Probability Theorem and Radiation.* **A. Einstein.** (Ann. d. Physik, 47. 7. pp. 879–885, Sept. 3, 1915.)—A mathematical discussion of M. v. Laue's treatment. [See preceding Abstract.] E. H. B.

97. *Quantum Theory and Hydrogen Atom.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 173–186, July, 1915.)—A mathematical treatment of the subject. [See Abs. 1192 (1915).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

98. *Origin and Maintenance of the Earth's Charge.* Part I. **W. F. G. Swann.** (Terrest. Magnetism, 20. pp. 105–126, Sept., 1915. Paper read before the Am. Assoc. for Advancement of Science, Aug., 1915.)—It is an established fact that at practically all times and over practically the whole of the earth's surface the potential gradient is of such a sign that the potential increases with altitude, and consequently there is a negative charge distributed over the surface of the earth. Owing to the conductivity of the air this charge is constantly leaving the earth at a rate which the author calculates would reduce the potential gradient to 1/10th of its initial value in 10 minutes if no fresh charge were supplied. Further, the atmosphere is positively charged, so that the potential gradient decreases with increase of altitude. One hypothesis to explain the fact that the charge on the earth is not depleted is that negative electricity is fed into the earth from the outside in some unspecified manner, in which case the vertical conduction current which leaves the surface must be dissipated again into space. The effects following on this hypothesis are investigated, and it is found that such a theory does not lend itself very naturally to an explanation of the observed phenomena. A second hypothesis is that electricity may be deposited by some agency in the atmosphere and upon the earth below, the net amounts for the atmosphere and the earth being equal but of opposite sign, positive for the former and negative for the latter. If such replenishment takes place at one portion of the earth only, as is sometimes supposed, certain difficulties are introduced in the way of obtaining an approximately equal potential gradient over the whole surface, and it is found that unless the resistance of the upper layers of the atmosphere is extremely small the potential gradient would be zero at all points other than those where the replenishment was in progress. Such small resistances may, however, be assumed according to present evidence upon the subject, so that this difficulty is not serious. Various theories are discussed briefly, and then the possibility of finding a satisfactory explanation of the observed facts by means of a convection current theory is looked into in detail. This theory supposes that positive charges drawn by some means from the earth may be carried up into the higher levels of the atmosphere by means of ascending positively-charged air, so that the "conduction" current of positive electricity downwards would be balanced by this "convection" current upwards. There is considerable difficulty in seeing how the positive charges could be carried to any great height by this means, as it is proved that they would quickly be dissipated from the masses of air which carried them, so that the convection and conduction currents would be reduced to a very small value within about 1000 m. height. From this it follows that the potential gradient would also almost vanish within this height. Thus this theory does not seem to afford a satisfactory explanation of the facts. In a later paper the author proposes to pursue the subject further. J. S. Di.

DISCHARGE AND OSCILLATIONS.

99. *Electrical Conductivity and Luminosity of Flames containing Salt Vapours.* **H. A. Wilson.** (Roy. Soc., Phil. Trans. 216. pp. 63–90, 1915.)—The author describes a stroboscopic method of measuring the velocity of a

flame by injecting into it a series of puffs of salt spray which, observed through the perforations of a rotating disc, can be made to appear stationary. The velocity v is given by $v=n(x_1-x_2)$, where n is the number of puffs injected per sec. and x_1, x_2 are the heights of two neighbouring puffs as seen through the disc. On applying a downward electric field the positions of the puffs are unaltered so that the luminous vapours in a Bunsen flame are not appreciably deflected by an electric field. The motion of a luminous streak observed by Lenard, Ebert, and Andrade was probably due to the deflection of the flame containing it, which deflection is difficult to estimate and allow for. Even when the field is strong enough to produce an arc the positions of the puffs are unchanged although luminosity appears in other parts of the flame. The results suggest that positive ions can be made to move out of the luminous vapour by an electric field, and that these positive ions are not luminous but can form luminous vapour after recombination.

The velocity of the positive ions was measured by finding the potential gradient in the flame necessary to make them move down against the flame gases from a bead of salt inserted just under the upper electrode. The velocity is about 1·0 cm./sec. per volt/cm. and is the same for all salts. The author shows that the discrepancy between this and the much higher values found previously by him and by Lusby [Abs. 367 (1912)] is due to salt vapour getting into the flame below the salt bead. In the present work all flame gases and salt vapour are carried away by a chimney, which the flame enters. In the absence of this chimney, the higher values are obtained. Hence Andrade's criticism [Abs. 1567 (1912)] of the previous experiments is correct.

A series of experiments on the conductivity and luminosity of salt flames was carried out, using two similar flames in each of which the current between parallel electrodes, and the potential gradient in the flame, could be measured. One flame was kept constant and the conductivity and luminosity of the other under varying conditions were compared with it. The luminosities were compared by a spectro-photometer. For electrodes close together the current depends mainly on the fall of potential at the negative electrode and the conductivity of the flame in the uniform potential gradient between the electrodes has little influence upon the current: thus the current under constant p.d. between the electrodes cannot be taken as a measure of the conductivity. The conductivity is here taken as the ratio of the current to the uniform potential gradient in the flame, where Ohm's law holds. It is found that both the conductivity and luminosity of a flame containing NaCl vary nearly as the square root of the concentration of the salt vapour in the flame; and the conductivities and luminosities of chemically equivalent amounts of NaCl and Na_2CO_3 are equal.

The effects upon luminosity and conductivity of adding various amounts of HCl and chloroform to a sodium flame were determined. It is concluded that the effects are due to a change in the character of the flame and not to chemical action. It was also found that the presence of a large amount of K_2CO_3 does not change the luminosity due to Na_2CO_3 although the K_2CO_3 greatly increases the total conductivity. This seems to show conclusively that the luminosity is not due to positive ions. The K_2CO_3 increased the number of negative ious present by nine times and therefore must have diminished the number of positive Na-ions in the same ratio. That the negative ions from K_2CO_3 do combine with the positive from Na_2CO_3 is shown by the fact that the conductivity of the mixture of sodium and potassium carbonates is less than the sum of their separate conductivities.

The same apparatus was used to determine the relation between conductivity of the salt flame and the concentration of salt vapour in the flame. It is found that the variation of concentration, k, with the conductivity, c, for alkali salts can be represented by the formula $10^4k = [(c^2 - 1)/c](b + ac)$, using proper values for the constant a and b, for each salt. This equation is also deduced from the ionic theory, and it is shown that $b/(b + ac)$ is the fraction of salt molecules ionised in the flame. The percentage of salt molecules ionised when the concentration is very small is for Cs, 91 % ; Rb, 69 % ; K, 58 % ; Na, 1·6 %. The constant b is proportional to the molecular weight of the salt. According to the theory this shows that all salts give negative ions having the same velocity in the same electric field.

The conductivity of a mixture of salts agrees with that calculated from the ionic theory. It is also shown that alkaline chlorides and carbonates impart equal conductivities to the flame for chemically equivalent concentrations. In earlier experiments (when the current due to a constant p.d. between the electrodes was taken as a measure of the conductivity) it was found that at large concentrations oxysalts gave greater currents than the haloid salts. The present experiments show that the conductivity is the same for both at all concentrations. T. H.

100. *Carbon Consumption in Electric Arc.* **W. G. Duffield.** (Roy. Soc., Proc. 92. pp. 122–143, Dec. 1, 1915.)—Describes experiments to determine the rate of consumption of d.c. arc-lamp carbons (i) at various arc lengths and with various currents, and (ii) in its bearing on the luminous radiation from the arc. Under (i) it is found that the loss of weight per coulomb for a given current density increases with increasing arc length until a nearly constant value is reached at about 8 mm. This is true for both electrodes, although there is a difference in the initial behaviour of anode and kathode. The general shape of the curve obtained is explained by the increasing oxidation of the hot poles as the arc is lengthened, a limit being reached when further increase of length has no effect on the amount of air which has access to them. For long arcs the loss per coulomb decreases with increasing current. For very short arcs (order of 0·1 mm.) at all current strengths from 2 to 100 amps. the loss per coulomb from the kathode is constant and about $3{\cdot}2 \times 10^{-5}$ gm., remarkably near the electrochemical equivalent of tetravalent carbon. It is concluded, therefore, that the loss of an atom of carbon from the kathode of a very short carbon arc is accompanied by the transfer of four electronic charges of electricity, whereas in long arcs there is an additional loss due to combustion or evaporation. The influence of the results of these experiments on existing theories of the electric arc is discussed at considerable length, and the mechanism of the short arc is separately considered. In the last section of the paper it is shown that increased rate of consumption of the electrodes means increased luminosity in the arc. J. W. T. W.

101. *A Mode of Studying Damped Oscillations by the Aid of Shrinking Vectors.* **D. Robertson.** (Inst. El. Eng., J. 54. pp. 24–34, Dec. 1, 1915.)—The equations for a simple oscillating circuit are deduced in a manner exactly analogous to that ordinarily applied to sustained alternating currents. The amplitude of the oscillation is represented by a rotating vector, but its extremity traces out a logarithmic spiral instead of a circle, while the rate-of-change vector is $(90° + \psi)$ ahead instead of 90°, and has an amplitude $(\omega^2 + \alpha^2)^{1/2}$, or ω_0, times as great instead of ω. The converse holds for the time-integral.

From these premises, the differential equation for a shrinking sine function is deduced by a purely elementary geometrical method, and the ordinary equations for such functions are obtained. The special case of critical damping is separately dealt with, and then the paper proceeds to "over-damped oscillations," for which a new representation of an exponential function is required. This is given by a vector spinning about the axis of projection (the non-periodic axis), sweeping out a cone around that axis, while its extremity traces a spiral on the cone. The velocity of spin is the "damping velocity," a. It is shown that an imaginary rotation about the ordinary periodic axis is a real spin about the non-periodic axis, and *vice versa*. The exponential values of the sine and cosine follow at once from this idea, and are given a tangible meaning, while at the same time the analogies between the circular and hyperbolic functions appear in a new light.

The equations for over-damped oscillations are easily deduced in this way, and the whole theory of simple oscillations, damped, critically damped, and over-damped (non-periodic), is thus brought within the range of elementary mathematics, while the mental picture afforded by the vector diagrams is of value even to the highly trained mathematician.

The method is applicable to vibrations of any kind, but the author has had electrical oscillations mainly in view, and concludes the paper by applying it to the cases of a condenser charged and discharged through an inductive resistance. The original paper must be referred to for mathematical details. AUTHOR.

102. *Silent Discharge in Gases at Atmospheric Pressure.* **S. Sachs.** (Ann. d. Physik, 47. 7. pp. 886–926, Sept. 3, 1915.)—The silent discharge at atmospheric pressure was experimentally studied in air, oxygen, CO_2, N, H, and a mixture of Ne and He. It was found that the presence of chemical processes in the silent discharge distinctly favoured the conductivity of the gas. The paper includes many tables and curves giving the details of the behaviour of each gas. [See Abs. 1554 (1911).] E. H. B.

103. *Radiation of Sparks from Oscillators.* **J. de Kowalski.** (Archives des Sciences, 40. pp. 336–339, Oct., 1915. Paper read before the Soc. Suisse de Physique.)—An experimental research from which it is concluded that oscillating electric sparks between metal electrodes emit a radiation only slightly absorbable by air or quartz but very absorbable by water. The radiation is but slightly dependent on the capacity in use. [See Abs. 1311 (1914).] E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

104. *Thermoelectromotive Force of Certain Iron Alloys.* **T. S. Fuller.** (Am. Electrochem. Soc., Trans. 27. pp. 241-248; Disc., 248–251, 1915.)—A study of the effect of composition on the thermoelectric force of certain base-metal alloys. Alloys of Fe-Ni, Fe-Cr, Fe-Co, Fe-Ni-Cr, and Fe-Ni-Mn were prepared by melting the requisite quantities either *in vacuo* or in an atmosphere of hydrogen. They were drawn out to wire 0·01 in. in diam. and a couple of each was formed with copper as standard; the junctions were maintained at 0° and 100° C. The results are represented by a series of tables and curves. For the binary alloys the thermoelectric force is plotted against the composition. An equilateral triangular diagram is used for the ternary alloys in which the perpendicular distance from the sides represents

the proportion of the constituents. The chief points raised in the discussion are: (1) lack of data on effect of carbon and silicon content; (2) effect of annealing; (3) method of representing the results for ternary alloys; (4) resistance of the alloys to oxidation. L. L.

105. *Vibration Electrometer.* **H. L. Curtis.** (Bureau of Standards, Bull. 11. pp. 535–552, 1915.)—A vibration electrometer can detect very minute alternating currents. The instrument described by the author is a modification of the quadrant electrometer. By means of it capacities of the value of 0·001 mfd. have been measured at 50 cycles with an accuracy about 10 times greater than can be obtained by any vibration galvanometer in the author's laboratory. For smaller capacities the advantage is still greater. It is useful only when the impedance of the bridge arms is very high, so that the current which flows through them is very small. It cannot be used at frequencies much above 100 cycles on account of the moment of inertia of the vane. In this instrument the four quadrants, taken in order, of a quadrant electrometer, are replaced by four insulated plates A, B, A′, B′, each 2 cm. × 1 cm. The two plates A and B which lie in the same plane are at a variable distance of about 1 mm. from the plane containing A′ and B′. The diagonally opposed plates AA′ and BB′ are electrically connected. A light Al vane, which can vibrate about a vertical axis, is supported between AB and A′B′ by means of a bifilar suspension. If an electrostatic charge is given to the vane, and an alternating e.m.f. is applied to the plates, the vane will vibrate in the period of the e.m.f. When in resonance, the amplitude will depend upon the damping, and as air damping is a large part of the total damping, the whole instrument is placed under a bell jar which can be exhausted. This electrometer can detect low-frequency alternating currents as small as 10^{-11} amp. The theory is developed mathematically, and the conclusions verified by experiment. The important conclusions are as follows:—(1) For any given adjustment, the frequency at which max. deflection is obtained depends upon the potential of the vane. As the latter increases the former decreases. (2) When the voltage on the vane is increased, the deflection for a given voltage on the plates increases more rapidly than the first power of the voltage. The sensitivity cannot be increased indefinitely in this way, since the frequency will become zero before the sensitiveness becomes infinite. (3) The deflection is inversely proportional to the damping. It is shown that the damping due to a well-constructed suspension is exceedingly small. (4) As the damping is decreased, the range of frequencies over which the instrument can be used is greatly diminished. Hence it is not important to decrease the damping beyond a reasonable point. (5) Some time is required before the amplitude becomes constant. This time increases as the damping decreases. (6) The power required to give unit deflection, at resonance, decreases in the same ratio as the damping.

Numerous curves are given in the paper. I. W.

106. *Simple Thermal Instruments for Current Measurement.* **W. H. Eccles and A. J. Makower.** (Electrician, 76. pp. 233–234, Nov. 19, 1915.)—If an air-bubble be formed in a horizontal glass tube containing a liquid such as alcohol, the application of heat to the outside of the glass near one end of the bubble will cause the latter to move towards the point of higher temperature. The heat may be generated by the passage of a current through thermo-junctions or through a wire of high resistance. When the glass tube

is straight and horizontal the instrument is very sensitive, but has no definite zero. This difficulty can be overcome by bending the tube in the middle till the two arms make an angle of about 170°; the bubble is then stable when at the top of the bend. In the first instrument described the heat was generated in a No. 47 Eureka wire only a few mm. long. The bubble, which was 5 mm. long, was formed in a tube of 3·8 mm. bore and 0·38 mm. wall thickness; its position was read by means of a microscope. The form of instrument that the authors suggest consists of such a tube mounted on a hinged base in such a way that the bubble can be brought back to zero by turning a screw provided with a vernier head. Various modifications of this instrument have been tried by the authors, and their experiments indicate that the motion of the bubble is due to change of surface tension with the temperature. The authors point out (1) that the instrument is very simple in construction; (2) that the parts carrying current do not come near any metal masses (hence freedom from capacity troubles); and (3) that the inductance is very small. For these reasons it is especially suitable for the measurement of h.f. currents.

I. W.

107. *A Highly Sensitive Electrometer.* **A. L. Parson.** (Phys. Rev. 6. pp. 390–399, Nov., 1915.)—Illustrated description of a modified form of quadrant electrometer with low electrostatic capacity (4 to 5 cm. and upwards). In practice the electrometer can detect 3×10^{-6} volt (with needle potential and scale distance 5 m.).

L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

108. *Phase Difference of Sine Currents.* **G. Lignana.** (Accad. Sci. Torino, Atti, 50. pp. 334–340, 1914–1915.)—A detailed study of the practical applications of the method devised by G. Ferraris for measuring phase differences, in which the two currents are sent through coils normal to each other and the induced e.m.f. is measured in a movable coil turning about the axis of symmetry of the two fixed coils.

E. E. F.

109. *Non-uniform Distribution of Alternating Currents in Iron Conductors.* **L. Lombardi.** (N. Cimento, 10. pp. 234–248, and 249–255, Sept.-Oct., 1915.)—Instead of confining his determinations to the equivalent thickness of "skin" having a purely ohmic resistance, the author determines separately the resistance and the inductance, as well as the hysteresis loss, in iron rods 1, 2, and 3 cm. in diam. respectively, and several metres long, bent into circles. The measurements of effective resistance show a mean divergence of 3·7 % from the theoretical values in four specimens, but the deviations are in both senses. The inductances show a better agreement. The author adds an investigation of the distribution of periodic fluxes of magnetic induction.

E. E. F.

110. *Magnetic Study of Mechanical Deformation.* **H. Hanemann** and **P. D. Merica.** (Am. Inst. Mining Eng., Bull. No. 108. pp. 2371–2385, Dec., 1915.)—The principal material used was a soft iron low in carbon. A wrought iron, a sample of nickel, and a nickel steel were also used. These, in the form of rods, were turned down to the test shape desired, and annealed at 950° C. in nitrogen or *in vacuo.* The magnetic measurements took place by means of the ballistic method, applied to the specimen while in the testing machine. Extensions were determined by an extensometer, the elastic limit being taken as that least value of the stress at which there remained a

permanent elongation of 0·0002 per cent. After demagnetisation, a B-H curve of a specimen was determined for zero load, and the effect of stress on magnetic induction found differentially by the use of an unstressed comparison bar; any change of stress was always preceded by demagnetisation of the bars. Induction-stress curves are given for iron which show the Villari point. The results are given somewhat as follows:—The permeability of iron is independent of the previous elastic history of the material if (1) the cycles of stress have been within the elastic limit, and (2) the number of cycles has been small. There is a close and nearly linear relation between the elastic limit of soft iron and the values of the stress at which the permeability maxima occur, as the material is elongated. The conclusion is reached that the magnetic method is applicable to the study of the previous mechanical history of such annealed iron as was investigated. The permeability of this material was not affected if kept under the elastic limit. Initial stress effects were observed in the material when tested as received, and also after quenching in water. G. E. A.

111. *Saturation Value of the Intensity of Magnetisation and the Theory of the Hysteresis Loop.* **E. H. Williams.** (Phys. Rev. 6. pp. 404–409, Nov., 1915.) —P. Weiss has shown that an alloy of Fe and Co in relative amounts represented by Fe_2Co gives a higher saturation value (I_m) for the intensity of magnetisation than either Fe or Co alone. D. Yensen has also observed that the magnetic properties of pure iron are greatly improved by melting the iron in a vacuum. In the present paper the author investigates the value of I_m for the alloy Fe_2Co prepared under various conditions and has also tested some samples lent by P. Weiss. It will be seen from the following data taken from the paper that the effect of melting under diminished pressure and forging is to increase the value of I_m.

	I_m.		I_m.
Commercial steel	1751	Fe_2Co (forged with steam hammer. Melted under pressure 1 mm. Hg)	2050
Electrolytic iron (melted under pressure 3 mm. Hg)	1798	Fe_2Co (forged with steam hammer. Melted under pressure 0·5 mm. Hg)	2056
Cobalt (pure, Stifler)	1421	Fe_2Co (melted and cast at atmospheric pressure. Sample from P. Weiss)	1752
Cobalt (99 % pure. Melted under pressure 1 mm. Hg)	1504	Fe_2Co (re-melted under 0·5 mm. Hg. Forged)	2088
Fe_2Co (not forged. Melted under pressure 3 mm. Hg)	1791		
Fe_2Co (hand forged. Melted under pressure 3 mm. Hg)	1962		
Fe_2Co (forged with steam hammer. Melted under pressure 3 mm. Hg)	1977		

The author also tests the hysteresis loss theory of J. Kunz [Abs. 1444 (1912)]. According to this, the hysteresis loss, between fields $\pm H_1$ and corresponding $\pm I_1$, is a function of H_1, I_1, I_m, and H_c (coercive force). The hysteresis loops and constants involved were determined for Fe_2Co before and after annealing and also for a sample of pure iron after annealing. The losses determined experimentally agree well with those calculated by the theory. L. L.

112. *Temperature Coefficient of Magnetic Permeability within the Working Range.* **R. L. Sanford.** (Bureau of Standards, Bull. 12. pp. 1–10, 1915.)—In magnetic measurements made at the Bureau of Standards it has been found that the heating effect of the current, employed to produce fields of 100 to 800 gauss, changes appreciably the value of the induction for a given field. The usual practice, when an accuracy of 1 % is desired, has been to immerse the coil in an oil bath maintained at a constant temperature of 25°. The object of the present investigation is to determine the magnitude of the temperature effect and to see whether it is possible to apply a correction in order to reduce the measurements made at any temperature to some standard temperature. The materials investigated were cast-iron, wrought iron, and low-carbon steel in the form of rings. These were subjected to various heat treatments. The ballistic method of measurement was employed and the results are represented in the paper by a series of curves. The chief conclusions to be drawn are :—(1) The temperature coefficient of magnetic permeability though small cannot be neglected in measurements of high accuracy. (2) On account of the wide variation in the temperature coefficient not only for different materials but for the same material with different heat-treatments, correction cannot be made to standard temperature from data obtained from other materials. (3) Control of temperature is essential if errors as great as 1 % are to be avoided in magnetic measurements. L. L.

113. *Magnetic Testing of Bars of Straight or Curved Form.* **A. Campbell** and **D. W. Dye.** (Inst. El. Eng., J. 54. pp. 35–45, Dec. 1, 1915. El. Rev. 77. pp. 859–861, Dec. 31, 1915. Abstract.)—The authors describe some methods they have recently employed in magnetic testing where the magnetising field H is measured by the aid of subsidiary search coils and not calculated from the amp.-turns and mean length of the magnetising coil. Such methods have been previously employed by Ewing and Low, Madame Curie, Denso, and Gumlich and Rogowski [Abs. 497B (1912)]. In the present investigation two methods of measuring H have been used. In the first, the differential method, two coils of slightly different diams. but containing the same number of turns are wound concentric with one another and with the specimen, the coil of smaller diam. being close to the test bar. These coils are connected in opposition, and the e.m.f. induced in them when the magnetising field is increased is proportional to the increase of field in the annular space they enclose. A third coil of still larger diam. may be connected in opposition with the second, and the increase of field in the annular space enclosed by the second and third obtained. The increase of field at the surface of the bar can thus be deduced.

In the second method a small search coil is placed close to the surface of the specimen but not linked with it, its axis being parallel to the surface and in the direction of H. For a curved bar the coil is wound on a flat paper core, which is well varnished with cellulose acetate enamel, bent round and allowed to dry hard. When the coercive force and remanence of a magnetic substance are to be measured, the magnetising fields must be sufficiently strong to produce saturation. In the case of a thin specimen (0·5 cm. diam.) or an equivalent bundle of strips the authors use the Isthmus method of Ewing. They dispense with the elaborate coned pieces, it being found sufficiently accurate to fit the ends of the specimen into thick soft-iron discs which may be separated from the laminated magnet limbs by air-gaps 1 or 2 mm. in width. The specimen is not rotated through 180°, but the magnetising field reversed. The time lag was practically negligible. Inactive area in a bundle of strips is compensated for by a small mutual inductometer whose primary is in series with the magnetising circuit and whose secondary is in opposition to the B search coil. For testing thicker bars or rods (up to 2·5 cm. diam.) a ring yoke apparatus similar to a recent design by Gumlich was employed.

The paper contains curves showing the results of B-H tests on electrolytic iron, mild steel, silicon iron sheet, magnet steel, cast-iron, cobalt, invar, nichrome, electrolytic nickel and a nickel steel with 19·9 % Ni. In an appendix the authors refer to magnetic potentiometer methods for practical testing. Chattock [Phil. Mag. 24. p. 94, 1887] described such a method, and recently Rogowski, R. Goldschmidt, and F. Goltze have made measurements with apparatus designed on this principle. L. L.

114. *Magnetic Survey of Pacific Ocean.* **L. A. Bauer** and **W. J. Peters.** (Terrest. Magnetism, 20. pp. 95–103, Sept., 1915. Paper read at a meeting of the Am. Assoc. for Advancement of Science, San Francisco, 1915.)—This was organised by the Carnegie Institution, and a preliminary survey was made in the *Galilee* between Aug., 1905, and June, 1908, swings of the vessel being made for the determination of the ship's deviation-coefficients and constants at the beginning and end of each cruise, and as frequently as practicable at sea and at ports of call. Although many precautions were taken in the fitting out of the vessel to remove magnetic matter, it was realised that a specially built non-magnetic ship would in the end prove most efficient and economical, and for this purpose there was obtained the *Carnegie*, and the programme was extended to include a magnetic survey of all the oceans, beginning in June, 1910, and designed to be completed in Dec., 1916. During the period Aug., 1905, to July, 1915, in addition to the observations made in the Atlantic and Indian Oceans, 689 values of the magnetic declination, and 578 each of dip and intensity have been observed in the Pacific Ocean aboard the *Galilee* and *Carnegie*. In addition, numerous observations have been made to obtain data for determinations of secular change, and instrumental comparisons made at the magnetic observatories of Sitka, Honolulu, Zi-ka-wei, Tokio, Christchurch, and Apia. A diagram is given showing the regions of all the largest errors of present charts of declination up to June, 1915. From a table giving the annual changes it is seen that, with few exceptions, those given by the *Galilee* and *Carnegie* are numerically larger than those given by the British and United States charts. Tables of corrections are also given for dip and horizontal intensity. Observations of atmospheric refraction, atmospheric electricity including potential-gradient, conductivity, and radio-active content, are referred to, and the usual meteorological data. Conductivity over the ocean was found to be greater than over land, and the radio-active content much smaller. C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

115. *Localisation of Projectiles—Appliances for Ozil Method.* **Buffon** and **F. Ozil.** (Archives d'El Médicale, 23. pp. 329–336, Nov., 1915.)—By means of the apparatus here described the bulb can be placed in any desired position with respect to the plate, and so the errors due to faulty centring and measurement of the height of the bulb are avoided. It gives the orthogonal projection of the markers upon the plate, and makes it possible to recover by means of a simple diagram that of the foot of the normal ray and that of the projectile. It further, in the operating room, makes it possible to place the patient in exactly the same position as that which he occupied upon the radiographic plate. The apparatus and method of using it are fully described. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

116. *Metallographic Research on the Thallium-Selenium System.* **T. Murakami.** (Kyōtō Coll. Sci., Mem. 1. pp. 153–159, May, 1915.)—This system of elements has been studied by means of the methods of thermal analysis. The selenium used had a melting-point of 217° C., while the thallium melted at 287° C., both of which values are somewhat lower than the true values for the pure materials. The equilibrium diagram indicates that Tl forms three compounds with Se, viz. Tl_2Se, TlSe, and Tl_2Se_3. The first forms brittle, dark grey, needle-shaped crystals which melt at about 368° C. TlSe is similar to Tl_2Se but is somewhat tougher and melts at 310° C. These two compounds are insoluble in each other in the solid state and form a eutectic which contains 21 % Se and melts at 283° C. TlSe reacts with the selenium melt at 265° C. to form $\beta\, Tl_2Se_3$, which in turn undergoes a transformation into the α form at 165° C. The Tl_2Se_3 forms a eutectic with Se which contains 52 % Se and melts at 150° C. Above the liquidus the melt separates into two layers, one having the composition between 55 and 97·5 % Se, and the other between 5 and 15·5 % Se.

The results of the thermal investigation were confirmed by microscopic examination. F. C. A. H. L.

117. *Reciprocal Solubility of Copper and Lead.* **B. Bogitch.** (Comptes Rendus, 161. pp. 416–419, Oct. 4, 1915.)—The addition of lead to copper results in the formation of the so-called "double layer" when the proportion of lead exceeds a certain value. According to some investigators this formation of the double layer is brought about by the difference in density of the two metals provoking an unequal separation of the two constituents at the moment of solidification, the two metals being miscible in all proportions in the liquid state. Other workers hold that the separation takes place in the liquid state. In order to settle the matter definitely the author has examined specimens quenched from certain temperatures above the melting-point of the particular alloy and also specimens withdrawn at different heights from molten alloys. The results show that copper and lead do form a double layer in the liquid state when the Cu-content lies between 34·5 and 87 %. This double layer can only exist between 940° and 975° C., the temperature at which the melt becomes homogeneous depending, of course, on the composition of the alloy. F. C. A. H. L.

118. *Platinum-Osmium Alloys.* (U.S. Pat. Reissue 13,691 [Original No., 1,055,119]. Met. and Chem. Eng. 13. p. 762, Oct. 15, 1915. Abstract.)—F. Zimmermann fuses Pt with from 0·5 to 10 % of osmium to obtain hard Pt alloys as substitute for Pt-Ir. One part of Os is, as to hardness effect, equal to 2¼ of Ir; alloys with more than 10 % Os are hardly workable; the Os alloys are ductile, of high tensile strength, and resist acids better than Pt-Ir. For jewellery alloys with 2 % of Os are recommended, for contact points alloys of from 6 to 10 %. The metals must be refined before being fused together. The natural metals cannot directly be used owing to their impurities [see also Abs. 1349 (1915)]. H. B.

119. *On the Heterogeneity of Steel.* **H. le Chatelier** and **J. Lemoine.** (Comptes Rendus, 161. pp. 373–378, Sept. 27, 1915. Rev. de Mét. 12. pp. 649–654, July, 1915.)—Commercial steels, when examined microscopically, often show an abnormal distribution of the pearlite, which, instead of being arranged evenly amongst the ferrite, is found in parallel bands. This striated appearance is ascribed to the influence of phosphorus, and the phenomenon provided an example of the law of distribution of a body between two solvents, carbon being much less soluble in phosphoric iron than in pure iron. For a long time experiments have been made with a view to characterising the localisation of the phosphorus directly, and have resulted in the discovery of the alcoholic cupric chloride etching reagent. In studying the effects of varying the composition of this reagent the authors have discovered that the presence of too little water results in difficulty in discerning the banded structure, since the etching time becomes unduly prolonged and no copper is deposited. On the other hand, the presence of too much water causes a too rapid deposition of copper, with the result that the surface of the specimen is coated uniformly, particularly in the case of low-phosphor steels. The most satisfactory composition of the reagent is as follows:—Methyl alcohol 100 cm.^3, water 18 cm.^3, conc. hydrochloric acid 2 cm.^3, cryst. copper chloride 1 gm. and cryst. magnesium chloride 4 gm. This reagent gives much more sharply defined outlines than Stead's reagent does, depositing a layer of copper on the regions poor in phosphorus. Quenching does not alter the position of the bands, the only effect being to render their internal structures more homogeneous. The formation of the bands is not due exclusively to phosphorus; it may also be brought about by the presence of Si, Mn, Ni, Cr, or any element which is soluble in iron and only diffuses slowly after solidification. The scale of the structure in steels is determined by the amount of work to which the steels have been subjected, and it is quite likely that the difference in quality of two steels of similar composition is determined by the sizes and compositions of the neighbouring zones. F. C. A. H. L.

120. *Experiments on the Corrosion of Molybdenum Steels.* **L. Aitchison.** (Chem. Soc., Trans. 107. pp. 1531–1538, Nov., 1915.)—Gives results of corrosion experiments on five molybdenum steels containing approximately 2·5, 5·0, 10·0, 15·0, and 20·0 % molybdenum. Prepared specimens were left in a 3 % sodium chloride solution, 1 % sulphuric acid, and in tap-water each for 77 days and in 10 % sulphuric acid for 48 hours. The results obtained show that the addition of a small percentage of Mo produces an increase in the corrosion in brine and both concentrations of sulphuric acid but not in tap-water. In the latter case the first additions cause a slight fall, followed by regular increases in corrosion. In the case of the brine and sulphuric acid tests considerable decreases in the corrosion take place after 15 % Mo is present. A close connection between corrosion and microstructure is shown to exist. C. O. B.

121. *Temperature of Reaction between Acheson Graphite and Magnesia.* **O. L. Kowalke** and **D. S. Grenfell.** (Am. Electrochem. Soc., Trans. 27. pp. 221–231; Disc., 231–239, 1915.)—Three distinct methods of procedure have been adopted with a view to determining the temperature at which carbon in the form of Acheson graphite reacts violently with magnesia. Firstly, weighed mixtures were heated at various temperatures and the loss in weight determined. This method gave indefinite results owing to the impossi-

bility of maintaining the furnace at a constant temperature. The values of the ratio, MgO : C, indicate, however, that the reaction proceeds according to the equation, $MgO + K \rightleftarrows Mg + CO$. Owing to the endothermic character of this reaction proceeding from left to right, the attainment of the reaction temperature by the mixed substances will be accompanied by absorption of heat from the surroundings and consequently by fall of temperature. The pyrometric results indicate that the reaction commences slowly at about 1950°—this temperature being dependent to some extent on the rate of heating—and becomes very violent at temperatures above 2000°. The latter temperature is sufficiently definite to serve as a fixed point for the calibration of optical pyrometers. Care must, however, be exercised to provide adequate vents to the reaction chamber in order to avoid an internal pressure, this producing fume in the pyrometer black-body tube; the power in the furnace should be kept constant.

Experiments were also made with a vacuum furnace of the Arsem type provided with a mercury manometer for determining the pressure inside the furnace. The fact that no great rise of pressure occurs at the reaction temperature provides additional evidence of the reversibility of the reaction.

T. H. P.

122. *Vapour Pressure of Thallium Amalgams.* **J. H. Hildebrand** and **E. D. Eastman.** (Am. Chem. Soc., J. 37. pp. 2452–2459, Nov., 1915.)—An extension to Tl-amalgams of the previous work [Abs. 1998 (1914)].

123. *Manganese-Nickel Alloys.* **A. D. Dourdine.** (Rev. de la Soc. Russe de Métal, 1. pp. 11–23 and 341–395, 1912. Rev. de Mét. 12E. pp. 125–132, April–May, 1915.)—The methods of thermal analysis have been applied to two series of alloys, one prepared from pure nickel and the other from commercial nickel containing 0·47 % Fe and 1·86 % Co; pure Mn being the alloying element in each case. The results indicate that these two metals form a continuous series of solid solutions with a minimum lying between 56 and 63 % Mn and at a temperature just over 1000° C. The presence of the Fe and Co in the commercial nickel does not appear to have an appreciable effect on the solidification point of that element, but in the alloys it appears to raise the temperature of the minimum. Between 38 and 71 % Mn, slight thermal disturbances occur in the solid state. These are discussed at some length.

F. C. A. H. L.

124. *The Anomaly of the Coefficient of Viscosity of Anisotropic Liquids.* **R. Schachenmeier.** (Ann. d. Physik, 46. 4. pp. 569–576, Feb. 26, 1915.)—When the temperature-viscosity curve of an anisotropic liquid is plotted, the curve shows a characteristic peak, the viscosity coefficient increasing rapidly on either side of the transition-point as the latter is approached. The author develops the mathematical theory of this phenomenon on the basis of O. Lehmann's assumption that the isotropic modification and the anisotropic modification each consist of a particular molecular state, and that in the neighbourhood of the transition-point both kinds of molecules are present. The formula is obtained $\Delta_2\zeta : \Delta_1\zeta = (T_3\mu_3 - T_2\mu_2) : (T_2\mu_2 - T_1\mu_1)$, where ζ is the viscosity, and μ the "degree of dissociation at the particular temperature."

A. F.

125. *The Theory of Gas Reactions.* **H. Löwy.** (Ann. d. Physik, 46. 4. pp. 561–568, Feb. 26, 1915.)—The author shows that the Liebig explanation of catalysis (transfer of molecular oscillation) can be upheld, qualitatively, in the case of gas reactions.

A. F.

126. *Calculation of the Molecular Heat of Metallic Sulphides and of the Electrochemical Potential of Sulphur.* **L. Rolla.** (N. Cimento, 9. pp. 197–208, March–April, 1915.)—In view of the complexity of the sulphur molecule, the Nernst-Lindemann formula is insufficient for the exact calculation of the specific heat of this element at constant volume. But the formula—

$$v = 2{\cdot}8 \times 10^{12} \sqrt{(T_f/mV^{2/3})},$$

in which v is the atomic vibration frequency at the melting-point, T_f the absolute melting-point, m the atomic weight, and V the atomic volume, gives $\beta v = 430$, and introduction of this value into the Nernst-Lindemann expression gives approximately the atomic heats of rhombic sulphur at constant volume over a moderately wide interval of temperature.

In the case of the oxides studied by Russell [Abs. 507 (1912)], the formula $v'/v = \sqrt{T'_f/T_f}$, in which v' represents the atomic vibration frequency of the element in combination, and T'_f the absolute melting-point of the compound, answers sufficiently well. But to three of the sulphides it cannot be extended, since cupric sulphide yields sulphur and cuprous sulphide when heated at the ordinary pressure, whilst cadmium and mercuric sulphides sublime without melting. The author has determined the specific heats of silver and lead sulphides at various temperatures with a view to ascertaining with what degree of approximation it is possible to measure the affinity between sulphur and lead or silver as a function of the atomic weights, densities, and melting-points, and of the thermal changes of the reactions Pb (or 2Ag) + S = PbS (or Ag_2S). The experimental numbers are found to be in good agreement with the molecular heats calculated by means of the expression—

$$\sum_{v=n}^{v=1} f(\beta v),$$

where n is the number of atoms in the molecule [compare Debye, Abs. 446 (1913)]. For U — A, where U is the thermal charge and A the affinity, the value 1610·66 cals. per gm.-equivalent at 18° is found for Pb + S = PbS and 521·26 cals. for $Ag_2 + S = Ag_2S$. The values of the affinity thus obtained indicate that the value found by Lucas [Abs. 3321 (1904)] and by Bruner and Zawadski (Zeits. Anorg. Chem. 65. p. 136, 1910) for the potential of sulphur against the hydrogen electrode should be modified to + 0·575. Assuming the accuracy of this number, the solubility product for fused lead sulphide is calculated to be $6{\cdot}7 \times 10^{-30}$. Calculation by means of this value, on the basis of Nernst's osmotic theory, indicates that the e.m.f. of the cell, lead | saturated solution of lead sulphide in N/10-sodium hydrogen sulphide | normal electrode, should be 1·089 volts. Experimental determination of this magnitude by a method substantially that used by Immerwahr [Abs. 1148 (1901)] gives at 18° the value 0·816 volt, which is in marked agreement with the value obtained by Immerwahr for amorphous lead sulphide under slightly different conditions, its divergence from the theoretical value being explainable by the uncertainty regarding the hydrolysis of sodium hydrogen sulphide, and by the paucity of our knowledge of the dissociation of lead salts. T. H. P.

127. *Changes of Mass and Weight involved in the Formation of Complex Atoms.* **W. D. Harkins** and **E. D. Wilson.** (Am. Chem. Soc., J. 37. pp. 1367–1383, June, 1915.)—The atomic weights of the first 27 elements, relatively to H = 1, are on the average 0·77 % less than integral multiples;

actual values include He 0·77, B 0·77, C 0·77, N 0·70, O 0·77, F 0·77, Na 0·77. This is, of course, identical with a statement that, when O = 16 and H = 1·0078, these seven elements give integral atomic weights, and that in the case of the first 27 elements the deviations are distributed equally above and below the integral values. The authors assume that the weights of the atoms are multiples of that of hydrogen, less a diminution of 0·77 % due to close-packing of these units: they calculate that the closeness with which a positive and a negative electron must approach to give a diminution of mass of 0·77 % is equal to 400 times the radius of the positive electron.

The probability that the sum of the deviations of the atomic weights from integral values would, as a result of mere chance, be as small as it is, amounts to 1 in 15 million when O = 16, but when H = 1 the ratio is only 1 : 10.

T. M. L.

128. *Structure of Complex Atoms. The Hydrogen-Helium System.* **W. D. Harkins** and **E. D. Wilson.** (Am. Chem. Soc., J. 37. pp. 1383–1396, June, 1915.)—From hydrogen to cobalt there is a strong tendency for the atomic weights of the elements to approximate to whole numbers, with a few striking exceptions, such as Mg and Cl. No such tendency appears amongst the heavier elements, the average deviations being as follows :—

Ni to Rb	0·247	Sr to Cd	0·247
M to Cl	0·199	Ta to V	0·260

Mere chance would give an average deviation of 0·25. Amongst the lighter elements it is possible to represent the integral atomic weights as formed by the union of atoms of hydrogen = 1, and of helium = 4. A table is given to show how this may be done: it is largely a reproduction of Rydberg's scheme, which makes the atomic weights fall in two series, viz. $4n$ and $4n - 1$; but the exceptions to this scheme are got rid of by using a perfectly general formula $4n + m$, so that if the atomic weight is $4n$ it is represented as all helium; if $4n + 1$, as helium plus one hydrogen, and so forth. T. M. L.

129. *Experiments on Supersaturated Solutions.* **M. Jones** and **J. R. Partington.** (Chem. Soc., Trans. 107. pp. 1019–1025, July, 1915.)—This paper deals with "supersaturated solutions of the second type," *i.e.* those in which deposition of solid is produced by rise of temperature. Supersaturation was produced under these conditions in solutions of calcium butyrate and calcium acetate.

The normal solubility of gypsum was found to be 14·92 millimols per litre at 19·6°, 15·41 at 40°; at 60° the value is 14·50. The specific conductivities were 0·001980 at 19·60°, 0·002892 at 40·00°, and 0·003624 at 59·95° C.; the specific conductivities in presence of finely-divided gypsum were 0·002068, 0·003153, and 0·003765, corresponding with the concentrations 15·67, 16·21, and 15·09; a marked increase of solubility was thus produced in each case. The solubility for different sizes of particles was calculated from the formula of Willard Gibbs, and the increases were found to agree very closely with those calculated for particles of radius $r = \mu$. It should be noticed that of the three temperatures selected one lies near a maximum of solubility whilst the other two lie above and below it.

T. M. L.

130. *A Relation concerning the Distribution of an Electrolyte between Water and some Second Solvent and its Dissociation Constant in Aqueous Solution.* **H. J. M. Creighton.** (Frank. Inst., J. 180. pp. 63–74, July, 1915.)—In this paper the author develops a general formula for the calculation of the con-

centration of the undissociated molecules of an electrolyte in water by means of data obtained by the measurement of the distribution of the electrolyte between water and a second liquid phase. The formula takes into consideration the possibility of association of the electrolyte in this second phase. The validity of the formula has been tested by means of measurements of the distribution of benzoic acid between water and benzene at 6°, and from the data obtained the concentration of the undissociated molecules of benzoic acid in the aqueous phase has been calculated. From these values a mean value of $7{\cdot}21 \times 10^{-}$ has been obtained for the dissociation constant of benzoic acid in water at 6°. Although this value of the dissociation constant of benzoic acid is somewhat higher than that obtained by the conductivity method, the use of the distribution method for obtaining an approximate value for the dissociation constant of an electrolyte, in those cases where the value determined by the conductivity method varies considerably with concentration, is suggested. [*Errata.* Ibid. pp. 741–742, Dec., 1915.] A. F.

131. *Osmotic Pressure and Concentration in Solutions of Electrolytes, and the Calculation of the Degree of Ionisation.* **S. J. Bates.** (Am. Chem. Soc., J. 37. pp. 1421–1445, June, 1915.)—The deviations of strong electrolytes from Ostwald's "dilution law" are explained on the assumption that electrolytes and their ions do not obey van't Hoff's laws of osmotic pressure. Assuming this to be the origin of the deviations, the author calculates that the osmotic pressure of the univalent ions is in general a few per cent. less than that calculated from van't Hoff's law; that of the undissociated molecules of strong uni-univalent electrolytes is considerably greater, the deviation amounting to 15 % even at 0·0001 N; the bivalent ions deviate much more than the univalent ions, but the undissociated molecules of bi-bivalent salts obey the law rather closely; hydration increases the osmotic pressure of both molecular species in the solution, but influences that of the undissociated molecules to a greater extent than it does that of the ions. T. M. L.

132. *Viscosity of Colloidal Solutions.* **E. H. Büchner.** (K. Akad. Amsterdam, Proc. 18. pp. 170–178, Sept. 8, 1915.)—According to Einstein, the viscosity of a liquid containing a great number of floating particles, is connected with the relative total volume of the particles. If the viscosity of the pure liquid is represented by z, that of the suspension by z', its volume by v and the volume of the suspended particles by v', then $z' - z = 2{\cdot}5\, v'/v$. This formula has been applied to gamboge suspensions by Bancolin, who obtained fairly satisfactory results; the factor, however, had to be taken 2·9 instead of 2·5 Admitting the formula to be correct, it is possible, conversely, to calculate the volume of the floating particles from measurements of the viscosity. If, then, the number of the particles be determined (*e.g.* ultramicroscopically), the volume of a single particle may be deduced. The results of preliminary work with molybdenum blue and iron hydroxide are given. E. H. B.

133. *Variation of Grouping of Emulsion Particles and Reversibility of Diffusion Phenomena.* **M. v. Smoluchowski.** (Phys. Zeits. 16. pp. 321–327, Sept. 15, 1915.)—A mathematical investigation of which the following are the chief points:—(1) A formula is derived which exhibits, in accord with Svedberg's measurements, the fluctuations of the concentrations of a colloidal solution. (2) The conception of the mean time of return is defined, and thus a criterion is obtained for the limits of validity of the thermodynamic irreversibility. [See Abs. 2088 (1914).] E. H. B.

134. *Heats of Dilution of Concentrated Solutions.* **W. S. Tucker.** (Roy. Soc., Phil. Trans. 215. pp. 319–351, 1915.)—The author has determined the heats of dilution of a number of solutions. The results obtained, together with values obtained by Thomsen, for heats of dilution are as follows:—

Hydrochloric acid ($N < 10$), $dQ/dN = (4082/N) - 272{\cdot}1$;
Nitric acid (Thomsen) ($N < 6$), $dQ/dN = (2020/N)$;
Sulphuric acid (Thomsen) ($N < 15$), $dQ/dN = (4666/N) - 196$;
Hydrobromic acid (Thomsen) ($N < 10$), $dQ/dN = 3356/N$;
Acetic acid (Thomsen) ($N < 10$), $dQ/dN = -(63{\cdot}49/N) + 40{\cdot}84$;
Sodium hydroxide ($N < 6$), $dQ/dN = -(7840/N) - 980$;
Lithium chloride ($N < 6$), $dQ/dN = (6968/N) - 871$;
Ammonium nitrate ($N < 10$), $dQ/dN = -(1172/N) + 48{\cdot}77$.

The following general conclusions are drawn:—(1) In spite of the varying thermal effects obtained on diluting different solutions, these effects may be expressed in a simple manner for the range over which the solutions may be considered concentrated. (2) When the solutions become more dilute, they, at the same time, become more complex. (3) Those thermal changes occur in strong aqueous solutions which suggest that the solute is dissolved, not in water, but in some definite hydrate of the solute, in general containing a large number of molecules of water. In special cases, however, such as that of acetic acid, the water molecules may be few in number, while with nitric and hydrobromic acids the solvent becomes pure water. (4) Calcium chloride does not show the effect in so marked a degree, probably because it is impossible to work with solutions of the same relative strength. A. F.

135. *Accurate Method for the Measurement of the Conductivity of Electrolytes.* **W. A. Taylor** and **H. L. Curtis.** (Phys. Rev. 6. pp. 61–64, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—The authors have studied the influence of various factors on the determination of the conductivity of solutions by means of an alternating current. It was found that there is no measurable change of resistance with change of voltage, provided the cells, solutions, and bottles used to hold the solutions are kept scrupulously clean. The slightest trace of grease or dirt, however, causes a change in resistance with change of voltage. This seems to be a good test for perfect conditions for measurements. It was also found that, with bright Pt electrodes, there is a change in resistance with change in frequency, and that this difference depends on the size of the electrodes, the largest electrodes giving the smallest change in resistance. There is also a change in resistance with change of frequency. In the case of platinised electrodes with 1-in. electrodes, no difference could be detected in the resistance measurements at 500 and 1000 cycles. With ½-in. platinised electrodes, however, a small change in resistance with change in frequency was observed in concentrated solutions, but this disappeared entirely with N/20 NaCl. A. F.

136. *Heats of Equilibrium and the Law of Saturated Solutions.* **A. Colson.** (Comptes Rendus, 161. pp. 586–589, Nov. 15, 1915.)—In accordance with the well-known thermodynamic equation, the change of solubility of a compound with the temperature is closely connected with the limiting heat of solution. These heats of solution have been determined in several cases by the author. In the case of common salt, the author finds the heat of equilibrium changes sign at about 0°, and there should therefore be a corresponding change in the solubility. As a matter of fact, however, the solubility increases regularly from —15° to + 108°, and the author therefore concludes that we have here a contradiction between the classical formula and the facts. A. F.

137. *Passivity in Connection with Ferrous Alloys of different Composition and Structure.* **H. W. Moseley.** (Am. Chem. Soc., J. 37. pp. 2326–2338, Oct., 1915.)—In the study of passivity of iron there has been little or no attempt to correlate the property with physical structure. The author has therefore imposed passivifying conditions on iron alloys of widely varying composition and structure in order to fill this gap in our knowledge. It was found that iron alloys of very different composition can be rendered passive by making the alloy act as anode in an electric circuit. The current density required to produce passivity varies with the electrolyte but is not related in any simple way with the composition or structure of the alloy. It appears that the change from the active to the passive state is not an instantaneous one, but that there is a gradual adjustment towards a new condition of equilibrium, since in the majority of the experiments less iron goes into solution as the current density necessary for passivifying is approached. When the circuit was broken the anode lost its passivity. In general, metals with a low solution tension, passivify at a lower current-density than those with high solution tension. F. C. A. H. L.

138. *Electro-deposition of Smooth Solid Lead from Lead Nitrate Solutions.* **F. C. Mathers** and **A. McKinney.** (Am. Electrochem. Soc., Trans. 27. pp. 131–138; Disc., 138–140, 1915.)—The authors have succeeded in obtaining smooth, coherent lead deposits from lead nitrate solutions, the deposits being as good as those obtained from any other lead bath. The best composition of the bath is as follows: Ten per cent. lead nitrate, 2·5–5 % acetic acid and 1 % of the residue from the commercial extraction of Curaçao aloes in the manufacture of aloin. Crude aloes may be used in the place of the aloes residue, but the deposits are not so good. The aloes or the residue should be dissolved by warming in the acetic acid before adding the lead nitrate solution. The bath should not be filtered before using. A current density of 0·4 amp./dm.^{2} (3·7 amps. per sq. ft.) may be used. Free acetic acid is necessary in the bath to avoid the formation of basic salts. Free nitric acid greatly hastens the deterioration of the bath. The baths have a life of only 6 or 7 weeks, after which the deposits become spongy, so that the practical utility of the bath is doubtful. Full details are given: (1) of the effects of current density and voltage; (2) of the current efficiency, and (3) of the properties of the kathodes. A large number of addition agents were tried in place of the aloes, but none of them approached the latter in efficiency. [See Abs. 1316 (1909).] T. S. P.

139. *Formation of Magnesium Sub-oxide in the Electrolytic Preparation of Magnesium.* **F. C. Frary** and **H. C. Berman.** (Am. Electrochem. Soc., Trans. 27. pp. 209–217; Disc., 217–219, 1915.)—Whenever magnesium oxide is present in the fusion of magnesium potassium chloride used in the electrolytic preparation of Mg, a dark-coloured substance is produced, together with metallic Mg, which rapidly liberates hydrogen from water. It is not Mg in the form of a "metal fog," as it does not react upon a solution of anhydrous nickel chloride in absolute alcohol, whereas metallic Mg does, with the liberation of Ni. Attempts to isolate the pure material from the powdered electrolyte after electrolysis, by the method of flotation, were not successful, since when

finely ground it is rapidly oxidised in the air. From a consideration of their results, the authors conclude that the dark substance is a magnesium sub-oxide. It is not formed by the mere action of Mg on the oxide in the presence of the molten double salt at a bright red-heat; apparently it is only obtained by the electrolytic reduction of magnesium oxide present in the molten electrolyte. When an electrolyte free from magnesium oxide is used, and the formation of the oxide is prevented by the passage of a current of dry hydrogen chloride through it during electrolysis, no magnesium sub-oxide is produced. [See Abs. 1653 (1910).] T. S. P.

140. *Electro-deposition of Nickel.* **C. W. Bennett, C. C. Rose** and **L. G. Tinkler.** (J. Phys. Chem. 19. pp. 564–568, Oct., 1915.)—Experiments have been carried out on the electro-deposition of nickel from acid and alkaline solutions, using both stationary and rotating electrodes. It is shown that with nickel ammonium sulphate solutions the efficiency of deposition on a rotating kathode, as well as on a stationary one, may be changed by changing the concentration of the hydrions. If the solution is maintained just sufficiently alkaline, a high efficiency of deposition is attained, and this efficiency is maintained for long periods when the kathode is rotated. When the concentration of the hydrions is practically zero, as in the case of a strongly alkaline solution, nickel is deposited more easily than the other ions, but with low efficiency. The low efficiency is occasioned by the impoverishment of the solutions in Ni ions. Rotation of the kathode prevents this impoverishment, and therefore tends to increase the efficiency, whereas in the cases of solutions where hydrions are present, the rotation of the kathode tends to prevent impoverishment of hydrions and consequently decreases the efficiency of nickel deposition. With a solution of 5 % nickel cyanide and 7 % potassium cyanide, using a current density of 5 amps./dm.^{2} a max. efficiency of 0·057 % was obtained with stationary electrodes, but on rotating the kathode the efficiency increased, the value of 0·13 % being obtained with 500 revs. per min., and 1·65 % at 1000 revs. per min. [See Abs. 2127 (1907).] T. S. P.

141. *Passivification of Iron by Nitric Acid.* **S. W. Young** and **E. M. Hogg.** (J. Phys. Chem. 19. pp. 617–649, Nov., 1915.)—Passivity of iron is defined as that state of the metal in which it is not attacked immediately by dilute nitric acid. Velocity measurements have been made of the reaction between iron and nitric action of different densities at 0°, 10°, and 20°. At 0° the velocity shows a marked fall when the density of the acid rises to 1·260 and the same concentration of acid marks the initiation of progressive passivification. This point, which is termed the "passive break," varies somewhat with the temperature. A degree of passivity, far greater than any produced by the strongest nitric acid, is brought about by exposure of iron to dry nitrogen peroxide gas, and the passive state seems to be the result of an equilibrium between the metal and nitrogen peroxide. Iron is indeed capable of absorbing nitrogen peroxide from any solution in which the gas is being produced, the rate of reaction being thereby diminished. The "passive break" is regarded as that concentration of nitric acid at which the reaction with iron begins to develop relatively large proportions of nitrogen peroxide. T. H. P.

142. *Etching Reagents and their Applications.* **O. F. Hudson.** (Inst. of Metals, J. 13. pp. 193–212; Disc., 213–221, 1915. Mech. Eng. 36. pp. 269–271, April 2, and pp. 280–286, April 9, 1915.)